TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(091) Suppl. #2		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Phase I - Guidelines for Post Socketed Foundations for 4-Cable, High-Tension, Barrier Systems		
Name of Project Manager(s): Reid, Faller, Sicking, Rosenbaugh	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211006001	**Other Project ID (i.e., contract #):** RFPF-09-02	**Project Start Date:** 8/15/2008
Original Project End Date: 7/31/2011	**Current Project End Date:** 10/31/2012	**Number of Extensions:** 2

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$73,549	$73,549	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$8,439	

Project Description:

High-tension cable barriers often incorporate socketed post foundations to simplify repair of the system after an accident. Barrier posts are designed to slide in and out of a ground socket for easy replacement of damaged components. Unfortunately, there have been numerous examples of socketed post foundations that are damaged during a cable barrier crash. In most cases, socket damage requires repair crews to either replace the socket itself or drive a post directly into the soil adjacent to the damaged component. Either situation defeats the purpose of using sockets and greatly increases the time necessary to restore a damaged barrier. The increased repair time translates into higher maintenance costs and increased risk to repair crews working adjacent to high-speed facilities.

Many existing socketed post foundation designs are constructed by drilling a hole in the soil, placing a steel sleeve in the hole, and backfilling with Portland cement concrete. Many of these designs do not have sufficient reinforcement to resist impact loads that are transmitted into the socket. Further, many of the sockets are too short to resist frost heave that can push the posts out of the ground. Thus, there is a need for general design guidelines that states can incorporate to assure that socketed post foundations perform as intended when used in the field.

Objectives/Tasks:

1. Conduct literature review on previous/current high-tension, cable systems.
2. Design new socket foundations for barrier posts.
3. Fabrication and dynamic testing of socketed foundations.
4. Analysis of test data and evaluation of socketed foundation designs.
5. Provide a written report documenting all work and conclusions.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, the Phase I research report was published and sent to the sponsors. The Phase I report documents the first round of dynamic testing and evaluation and contains the recommendations for the second round designs of the socketed foundations.

Money remaining in Phase I of the project was used to fund the first rounds of component testing originally projected to occur in Phase II. Through the advancement of Phase II, all of the remaining money has been spent from the Phase I fund, and Phase I will close at the end of this quarter. Please refer to the progress report for TPF-5(193) suppl #19 - RPFP-10-CABLE-1 for information on Phase II developments.

Anticipated work next quarter:

Phase I of this project will be closed. For continued development in Phase II of the project, please refer to the progress report for TPF-5(193) suppl #19 - RPFP-10-CABLE-1.

Significant Results:

PHASE I only:

Four socketed foundation designs were evaluated through dynamic bogie testing. All 4 of these first round designs experienced heavy damage in the form of concrete fracture and plastic deformation of the reinforcing steel. As a result, 4 new reinforcement designs were configured to provide additional strength to the socketed foundation. These recommended configurations will be evaluated in Phase II of this project.

Objectives/Tasks:	% Complete (Phase I only)
1. Conduct literature review on previous/current high-tension, cable systems.	100%
2. Design new socket foundations for barrier posts.	100%
3. Fabrication and dynamic testing of socketed foundations.	100%
4. Analysis of test data and evaluation of socketed foundation designs.	100%
5. Provide a written report documenting all work,conclusions, and recommendations.	100%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Additional (matching) funds for this project were obtained through a Mid-America Transportation Center program. This matching funding was used during the first round of design, testing, and evaluation for the socketed foundations. Thus, much of the original funding for this project remained as it was not used until the MATC funding was depleted. As a result, the continuing work which would have been conducted under Phase II of the project was being charged to the Phase I project until the funds are gone.

This Phase I project is to close upon the end of 2012.

Potential Implementation:

Upon successful completion of this project, State DOT's will have the option to use a socketed post foundation for cable barrier system posts. The socketed foundation will allow for quick, easy, and inexpensive repairs to damaged sections of the barrier.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #14	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)

Project Title:

Concrete Traffic Barrier Attachment to Deck Utilizing Epoxy Concrete Masonry Anchors

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Bielenberg, Dickey, Faller, Reid, Sicking	(402) 472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211020001		7/1/2009
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2011	11/30/2012	2

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$113,619	$106,661	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$12,042	

Project Description:

When properly installed, epoxy anchors have been shown to be capable of developing the full strength of the surrounding concrete. Hence, these anchors provide tensile and shear strengths comparable to any cast-in-place straight bar. In fact, because the epoxy is stronger than the surrounding material and it distributes anchor loads over a larger area of concrete, these anchors can be stronger than cast-in-place straight bars with similar embedment. Unfortunately, many cast-in-place bars are bent in order to increase anchor capacity. In this situation, epoxy anchors cannot normally match the strength of cast-in-place anchors, and additional anchors may be needed.

Note that rated capacities published by epoxy anchor manufacturers are based upon static load capacities. When used in conjunction with traffic barriers, epoxy anchors can resist much higher loads. Hence, it is inappropriate to design traffic barrier anchors based solely on published load ratings.

Further, in order to assure long term durability, all anchor components must have some sort of corrosion protection. Any dynamic testing conducted to determine the dynamic capacity of epoxy anchors must include the appropriate corrosion protection.

OBJECTIVE:

The objective of this research effort is to determine if epoxy masonry anchors can be utilized to anchor a crash barrier to bridge decks to allow the use of precast aesthetic concrete traffic barriers or in-board cast-in-place or precast concrete traffic barriers separating traffic and trail traffic without the need to cast reinforcing steel into the deck surface to anchor the barrier. The researchers should establish design criteria/parameters, i.e. embedment depth, size of acceptable bar(s), and strength or type of epoxy (preferably generic epoxy spec criteria) appropriate for this use.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

MwRSF implemented WisDOT's comments with respect to the draft report and printed the final report. This completed the project.

Excess funds from this project were requested to be transferred or placed in contingency for use in TPF-5(193) Suppl. #15 (Development of a Low Deflection Temporary Concrete Barrier).

Anticipated work next quarter:

None.

Significant Results:

Task	% completed
1. Literature search to identify published procedures for estimating dynamic strength of epoxy anchors.	100%
2. Review of standard, cast-in-place anchorage designs used by Pooled Fund member states	100%
3. Conduct 8 dynamic tests to determine shear and tensile capacities of selected anchors	100%
4. Develop predictive equations for chemical adhesive anchors based on dynamic testing.	100%
5. Conduct 8 dynamic tests to verify and/or revise the accuracy of the predictive equations	100%
6. Develop guidelines for anchoring concrete traffic barriers to reinforced concrete decks using epoxy anchors.	100%
7. Prepare draft and final research/test report.	100%

Total percentage of project completion = 100 %

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The development of guidelines for epoxy anchors would allow the use of precast concrete traffic barriers anchored to bridge decks - accelerating bridge construction and providing better quality concrete traffic barrier when aesthetic traffic barriers are utilized. It would also allow anchoring in-board, cast-in-place, or precast concrete traffic barriers to be used without the need for reinforcing steel protruding from the bridge deck surface and disrupting the machine finishing of the bridge deck (eliminating the need for hand finishing large areas of the bridge deck). Finally, development of epoxy anchor guidelines would allow a method for replacing/repairing traffic barriers on bridge decks without the need to remove and replace the bridge deck.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*		**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #15		☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Development of a Low Deflection Temporary Concrete Barrier		
Name of Project Manager(s): Bielenberg, Faller, Reid, Sicking	**Phone Number:** (402) 472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211022001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2009
Original Project End Date: 6/30/2011	**Current Project End Date:** 12/31/2013	**Number of Extensions:** 2

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$178,914	$94,341.00	70

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$51,689.00	

Project Description:

The objective of this research effort is to develop a joint stiffening mechanism for use in reducing the deflection of temporary concrete barrier installations without requiring anchorage of the barrier segments to the road surface. The joint stiffening mechanism will be developed for use with the Midwest Pooled Fund States 12.5-ft long, F-shape, temporary concrete barrier. The temporary concrete barrier joint stiffening mechanism will be designed and evaluated to meet the TL-3 requirements set forth in MASH-08.

Task	% completed
1. Project Planning and Literature Search	100
2. LS-DYNA Analysis of Barrier Offset to Drop-Off	30
3. Development of Design Concepts	90
4. LS-DYNA Analysis of Concept Designs	100
5. Fabrication of Design	100
6. TL-3 Full-scale Crash Testing with 2270P Vehicle	80
7. Analysis and Refinement of Design	40
8. Fabrication of Revised Design	0
5. TL-3 Full-scale Crash Testing with 2270P Vehicle	0
6. Summary Report	0

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

In the Fourth Quarter of 2012, progress was made on the analysis and refinement of the design for limiting concrete barrier deflection evaluated in the first full-scale crash test of this project. The design consisted of a cap plate bolted across the joint and a continuous tubes running along the sides of the barriers.

MwRSF has been determining what design modifications can be made to further reduce the system deflections. LS-DYNA computer simulations of the full-scale test were created and validated during this quarter. This work included developing finite element meshes of the tested design hardware, applying the design hardware to the previously developed free-standing barrier model, incorporation of the bridge deck edge, and simulation and comparison of the new model to the test results. The simulation models of the low-deflection design used in the first full-scale test demonstrated good correlation with the crash test. Validation of the model of the tested system has been completed and future work will focus on applying design changes to the simulation model to gauge there effectiveness.

Anticipated work next quarter:

In the First Quarter of 2013, MwRSF will continue the process of redesigning the reduced deflection PCB system. MwRSF will apply design changes to the model developed in this quarter in an effort to further reduce deflections. Some concepts that will be evaluated are reduction of the barrier gap at the joints, increased thickness and section of the structural elements, the use of additional attachment points between the barrier and the reduced deflection hardware, and increasing the barrier-to-ground friction.

Once these design modifications have been evaluated and their effectiveness estimated a revised design will be developed and presented to the sponsor. Once WisDOT has approved the revised design, MwRSF will conduct a second full-scale test using the revised design.

Significant Results:

A simulation model of the initial low-deflection design concept was developed that replicates the performance of the full-scale crash test. This model will allow MwRSF to evaluate design alternatives for the second full-scale crash test.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Currently MwRSF has developed and full-scale crash tested an initial design concept for reducing the deflection of PCB segments without constraining them to the pavement. The crash test of the initial design concept was successful and the design is currently undergoing refinement for a second test. As such, further analysis, design, and crash testing remain to be completed. Remaining work includes (1) analysis and refinement of the low-deflection PCB design tested in the first full-scale crash test for the project; (2) fabrication of the revised design; (3) a second TL-3 full-scale crash testing with the 2270P vehicle on the revised design; (4) the preparation of a final report with the implementation of WisDOT edits and comments; (5) the submission of published report copies to the sponsor; and (6) data archive.

Additionally, system fabrication costs for the full-scale test were higher than anticipated and additional, un-budgeted component testing was required as part of the research effort to better define the friction properties of the concrete barriers. Thus, with the remaining project tasks, it is expected that the project may exceed the current budget during the remainder of the research effort. Therefore, MwRSF requested permission to charge future excess expenditures for the work described above be applied to the surplus funds in completed Project Nos. MwRSF RPFP-WISC-5 and RPFP-WISC-3.

At this time, it was also expected that the remaining tasks for this project cannot be completed within the current time limit. Thus, we request a no-cost time extension of 12 months for this project, moving the closing date to December 31, 2013.

Potential Implementation:

Development of a joint stiffening mechanism for use in reducing the deflection of temporary concrete barrier will provide designers with a means to install temporary concrete barriers in limited deflection applications without anchoring the barriers to the roadway surface. This will reduce installation costs and damage to the road surface. In addition, installation and removal of the barrier system would be more efficient, thus reducing worker exposure.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:
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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #16	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Synthesis of Crash Cushion Guidance		
Name of Project Manager(s): Albuquerque D., Schrum K., and Sicking D.	**Phone Number:** 402-472-9332	**E-Mail** dsicking1@unl.edu
Lead Agency Project ID: 2611211023001	**Other Project ID (i.e., contract #):**	**Project Start Date:** July 1, 2009
Original Project End Date: June 30, 2011	**Current Project End Date:** December 31, 2012	**Number of Extensions:** 1

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$ 112,275	51,292 (+$7,608 for Suppl #26)	95%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,780 (+$315 for Suppl #26)	

Project Description:

Early in the design process, engineers typically have to select a crash cushion for a given location. However, there is little guidance to help designers to decide what type of crash cushion system to install (low maintenance crash cushions, non-gating crash cushions, gating crash cushions, sand barrels, etc…) based on the given conditions. This would include guidance as to which system would be suitable for installation at a given location based on factors such as ADT, number of lanes, and geometries. The selection of a given system can have a significant impact on the design of a location, and can also impact the construction, maintenance and user costs.
This project aims to provide guidelines for the selection of appropriate crash cushion designs for various installations.

The research objectives for this study consist of the following items:

1. Collect and synthesize guidance from various states on crash cushion use - concluded
2. Collect crash cushion construction and repair costs - to be updated w/ revised cost data
3. Conduct an economic evaluation of crash cushions - to be updated w/ revised cost data
   a. RSAP analysis of gating versus non-gating crash cushions
   b. Comparison of initial construction, maintenance and repair costs for low-maintenance versus conventional crash cushions
4. Develop a decision matrix for designers to select an appropriate system for a given location - to be updated w/ revised cost data

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Cost data from FHWA crash tests were obtained for each system from the manufacturers. With this data, the BC analysis was rerun, but the results were identical. This was due to the fact that installation cost was a larger component in the BC ratios and that the impact frequency of the modeled scenarios was small.

The effect of maintenance costs alone was studied in the original final report. With updated repair cost data, this study was conducted again, and the minimum impact frequency at which low maintenance systems was recommended changed from 0.82 impact events per year to 0.29 impact events per year.

The report was modified according to this new data and the subsequent conclusions. The report was sent to the Wisconsin DOT, the sponsoring agency, for review and comment.

Anticipated work next quarter:

After Wisconsin DOT approves the revised report, the report will be sent to the manufacturers who supplied cost data for review and comment. Any comments received will be reviewed and addressed.

Significant Results:

After rerunning the BC analysis with the updated repair cost information submitted by the manufacturers, the recommendations inferred from the analysis did not change. Only the minimum impact frequency at which to recommend a low maintenance system was affected.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Manufacturers will be given the chance to review the results of the findings following the implementation of the updated repair cost data. However, depending on the outcome of their review, this may delay publishing the final report which in turn will delay the project close date. Therefore, an extension may be requested.

Due to the amount of work remaining, this project is projected to have extra funds remaining at the time the project is complete. The funds in Project No. TPF-5(193) Suppl. #26 were exhausted prior to the completion of the project. Therefore, the overrun budget for Project No. TPF-5(193) Suppl. #26 is being posted to this project. To date, $7,608 has been posted for Project No. TPF-5(193) Suppl. #26.

Potential Implementation:

The guidelines implemented in this project will provide a useful tool for the selection of appropriate crash cushion designs for various installations.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Midwest Roadside Safety Facility, UNL

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #27		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Short-Radius Guardrail with Large Radii		
Name of Project Manager(s): Bielenberg, R., Faller, R., Reid, J., & Sicking, [	**Phone Number:** 402-472-9064 (Bielenberg)	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211042001	**Other Project ID (i.e., contract #):** TPF-5(193) Supplement #27	**Project Start Date:** June 30, 2010
Original Project End Date: June 30, 2013	**Current Project End Date:** June 30, 2013	**Number of Extensions:**

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$57,929.00	$5,627.00	30

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,428.00	

Project Description:

The objective of this research effort is to develop modified details for the Washington State short-radius guardrail system with a radius size up to 70 ft. The modified system would not be applicable for any other type of curved guardrail or similar installation. It should also be noted that these details will be based on engineering analysis and judgment. The recommended design will not be crash tested or considered to meet any test standard, such as NCHRP Report No. 350 or MASH.

Tasks	% completed
Review and summarize design details and prior crash testing on Washington State short-radius guardrail (WA-SRG)	100
Send summary to Wisconsin to decide on which short-radius system to model	100
Develop LS-DYNA FEA model of Yuma County-SRG system	95
Determine acceptable speed for 2000P crashes into Yuma County-SRG with LS-DYNA	0
Modify FEA model of WA-SRG to incorporate 70-ft radius	40
LS-DYNA analysis and design modifications for Yuma County-SRG with 70-ft radius	15
Prepare draft and final research reports	0
Obtain FHWA acceptance for modified Yuma County-SRG with 70-ft radius	0

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

During the Fourth Quarter of 2012, wood models for CRT posts were evaluated and compared to physical testing results. In addition, models of the Yuma County short radius guardrail system were created.

Wood post models of CRT posts used in the Yuma County short radius guardrail systems were created with different mesh sizes. The strong axis and off-axis (i.e., 45 degree) reactions of the CRT posts are critical to establishing the accuracy of the Yuma County W-beam system, and by expansion, to the remainder of the project. Once meshed post models were created, a simulated bogie impacted the post and the resulting energy, forces, bogie acceleration, and post damage were recorded. 1-in. and 1/2-in. mesh densities were attempted. Material property variations and energy absorption characteristics were evaluated, and one model was selected for future use in the short radius guardrail simulation. In addition, previous models of W-beam and short radius guardrail systems developed by MwRSF were consulted and a plan for modeling post-to-rail and rail-to-rail connections was created.

Based on the Yuma County short radius guardrail design, CAD was used to identify critical radii subject to two constraints: the angle encompassed by the short radius was 90 degrees, and posts were located both at the beginning and end of the radii segments. Incremental increases in the radius were plotted using different numbers of posts attached to the curved rail sections. Evaluation of the plots in CAD suggested three radii in addition to the Yuma County 8-ft radius which were most conducive to simulation. The three radii selected were 24, 48, and 71.5-ft radii. CAD models were then converted to finite element meshes and assembled together.

The first model simulated was the Yuma County system. After assembling models of the post-to-rail attachments, CRT posts, curved W-beam rail sections, and soil behavior, the system was simulated in an angled impact on the nose of the short radius system with a C2500 model to validate the Yuma County test results. Additional simulations with vehicles

Anticipated work next quarter:

In the First Quarter of 2013, models of larger radii systems will be evaluated using the same impact conditions as utilized in the Yuma County systems. Additional simulations with varying impact conditions may be required if additional critical locations for impact are identified. A report detailing the findings of this research project will also begin during this time period.

Significant Results:

Models of CRT posts used in the short radius guardrail were evaluated. Models of the Yuma County and larger-radius guardrail systems were also created.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

No results indicating implementation potential at this time.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #28		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Downstream Anchoring Requirements for MGS		
Name of Project Manager(s): Faller R., Reid, J., Sicking D., & Stolle C.	**Phone Number:** (402)-472-4233	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: 2611211043001	**Other Project ID (i.e., contract #):**	**Project Start Date:** July 1, 2010
Original Project End Date: June 30, 2013	**Current Project End Date:** June 30, 2013	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$235,065	$191,255	86%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$15,793 (6.7%)	$15,793	86%

Project Description:

Although downstream anchors are widely used on access-controlled freeways, these designs have never been crash tested under the current guidelines. Most states utilize an adaptation of various upstream terminals that incorporate at least one breakaway post and a cable anchor bracket. Because of the similarity of this design to upstream anchors that have been tested with a 2000P vehicle in the reverse direction, it is generally believed that existing downstream anchors will perform adequately when struck by light trucks. However, there is still some concern that these designs may not perform well when impacted by a small car. Further, the point at which these barriers can begin to contain and redirect an impacting vehicle (the end of length of need) has yet to be adequately determined.

This project aims to determine: (i) the safety performance of the MGS close to the end anchorage and (ii) the end of the length of need for the MGS barrier.

Tasks:

1) Literature review and survey of State DOTs current plans for trailing end guardrail anchorage - completed
2) Bogie tests to determine anchors strengths - completed
3) Evaluate anchorage capacity and potential for vehicle snag for selected standard designs using LS-DYNA - completed
4) Develop standard designs for downstream anchor systems - completed
5) Prepare final CAD details for preferred downstream anchorage system - completed
6) Assessment of the most critical system w/ two TL-3 full-scale crash tests under MASH - completed
   a) 2270P
   b) 1100C
7) Summary report - in progress

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The draft research report was partially subjected to an internal review. However, a complete internal review could not be completed as substantial changes were deemed necessary. This draft report shall cover the literature review, state DOT standards, component and full-scale tests, computer simulation efforts, as well as design guidelines. These design guidelines shall include recommendations for shielding hazards located in close proximity to the non-proprietary trailing end terminal, which are based on full-scale crash testing and simulations with the 2270P vehicle.

The TRB journal paper was modified based on comments from the reviewers. A modified paper was re-submitted in November 2012.

Anticipated work next quarter:

In the next quarter, the documentation and reporting of the research effort will be continued by implementing the Round 1 internal review comments. The submission of the draft report is expected by the end of the First Quarter in 2013. A journal paper on this project will be presented at the 2013 Annual Meeting of the Transportation Research Board.

Significant Results:

The pickup truck test resulted in a smooth vehicle redirection with considerable damage to the barrier system. This test indicated that the selected impact point was at or close to the end of the length of need.

The small car test revealed that considerable snag occurred near the downstream end of the cable anchorage system. This result confirmed initial concerns of increased snag at the downstream end, as observed in LS-DYNA simulations.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Problems related to the accuracy of the load cells delayed the execution of the bogie tests planned at the beginning of the project. A rupture occurred in the tow cable system that was used in a bogie test on the entire downstream anchorage system, thus causing a need for a re-test of the component test. A calibration of the wood material, necessary to reproduce a realistic failure of the BCT wood posts, caused some delay in the initial set-up of the numerical model. Finally, Dr. Mario Mongiardini took a new research position in Australia in October, thus the reporting process was delayed to await alternative personnel to take on the remaining efforts in 2013

Potential Implementation:

The results obtained from this project will give practitioners useful information about the safety performance of guardrail systems, in particular the MGS, at locations close to the downstream end anchorage. This information will be summarized in proposed guidelines for shielding hazards located in proximity of the tested downstream end anchorage. Also, the results of this project will provide a clear identification of the end of the length of need (LON) at the downstream segment of the MGS system.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): NE Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #29		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Minimum Effective Guardrail Length for MGS		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):** 2611211044001	**Project Start Date:** June 30, 2010
Original Project End Date: June 30, 2013	**Current Project End Date:** June 30, 2013	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$122,444	$90,590	75%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date

Project Description:

Objective: Determine the effective working width and overall performance of the Midwest Guardrail System (MGS) shorter than the current 175' test length.

Tasks:

1. Review prior TL-3 pickup truck crash tests into the MGS - completed
2. LS-DYNA simulations to evaluate performance of MGS with system lengths of 175 ft and shorter - completed
3. Select minimum effective length of MGS and prepare system CAD details - completed
4. Construct MGS with reduced length - completed
5. Crash testing and evaluation program under MASH (one 2270P test) - completed
6. Additional simulations to predict barrier deflections and working widths for varying system lengths - completed
7. Draft and final research reports - draft completed, undergoing internal review

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Task 6. Barrier VII and LS-DYNA simulations have been completed on the 62-ft 6-in. MGS and 50-ft MGS. The results and analysis from those simulations have been incorporated into the Minimum Effective Guardrail Length for the MGS report.

Task 7. The draft research report on crash test mgsmin-1 was updated to include the simulation effort and analysis on system lengths shorter than 75-ft. The draft report is undergoing an internal review.

Anticipated work next quarter:

Task 7. Update the draft research report based on the internal reviews. Submit paper to WsDOT for review.

Significant Results:

On April 5, 2012, MwRSF conducted one pickup truck crash test (test no. mgsmin-1) into a 75-ft long 31-in. tall Midwest Guardrail System (MGS) using an 2270-kg Dodge Ram according to the TL-3 safety performance guidelines of MASH. The truck was successfully contained and redirected, and met all relevant test criteria.

Barrier VII results indicated that the 62-ft 6-in. MGS system would produce similar rail loads and deflections, and anchor loads and displacements as the 75-ft MGS, at the MASH Test Level 3 conditions. LS-DYNA simulations performed on the 50-ft MGS suggest impacts between post nos. 3 and 6 will effectively redirect the 2270P vehicle and successfully shield a hazard. Because of limitations in the simulations, full-scale crash testing is recommended if systems less than 75-ft in length are desired.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

No problems have been encountered to date.

Potential Implementation:

This study will provide guardrail design guidelines for barrier lengths shorter than 175 ft. Designers will have full-scale crash testing evidence that very short guardrails function as intended as well as guidelines for estimating maximum barrier deflection as a function of guardrail length and impact location.

Simulations indicated successful redirection of an errant vehicle according to the MASH Test Level-3 conditions, for the MGS at 62 ft-6 in and 50 ft. Although the results of these simulations suggested successful redirection over a range of impact locations, full-scale testing is required for both the 62-ft 6-in MGS and 50-ft MGS before implementation could be recommended.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #32	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)

Project Title:

MGS Guardrail Attached to Culverts

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Rosenbaugh	402-472-9324	srosenba@unlserve.unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211046001	RPFP-11-MGS-2	7/1/2010
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
12/31/2013		

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$91,071	$79,842	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$10,013	

Project Description:

Some cross-drainage culverts are wider than 24 ft and therefore cannot be treated with a long-span guardrail system. Although it is acceptable to utilize the deformable, top-mounted post attachment design developed for metric height guardrail under NCHRP Report No. 350, many existing culverts are too narrow to accommodate the loss of roadway width that comes with a top mounted system. Recently, the MGS Bridge Railing system was successfully developed and crash tested using the TL-3 MASH guidelines. The bridge railing system attaches to the exterior, vertical edge of reinforced concrete decks. It is believed that this bridge railing system could be adapted to mount to the backside face of an existing culvert headwall. The objective of this research effort is to develop an MGS guardrail system that attaches to the outside vertical face of the culvert headwall for box culverts greater than 24 ft wide.

Objectives / Tasks

1. Literature review of current culvert designs
2. Design of MGS attachment to face of headwall
3. Dynamic bogie testing
4. Data analysis and evaluation
5. Written report documenting all design work, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

All component testing has been completed. Thus, the simulated culvert was removed from the test pit within the test site. Additionally, work has begun on the report documenting all testing and conclusions.

Anticipated work next quarter:

Work shall continue on the written report to document the design, testing, and conclusions of this project.

Significant Results:

A complete review of culvert designs used by Pooled Fund member states revealed a critical culvert design for testing and evaluation. A simulated culvert matching this critical design was been constructed. Four attachment concepts were developed, fabricated, and tested. Both the single anchor top mounted design and the side mounted design satisfied all resistance and damage requirements during lateral and longitudinal testing. Thus, these two designs will be recommended as attachment designs for the MGS Bridge Rail system attached to culvert headwalls.

Objectives / Tasks	% Complete
1. Literature review of current culvert designs	100%
2. Design of MGS attachment to culvert headwall	100%
3. Dynamic bogie testing	100%
4. Data analysis and evaluation	90%
5. Written report documenting all design work, testing, and conclusions	40%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

none

Potential Implementation:

Development of a new attachment for the MGS system to low-fill culverts will allow designers to install the MGS system on culverts wider than 24 ft without reducing the width of the overall roadway. In addition, it is anticipated that the new attachment design on the outside of the headwall will reduce construction and maintenance costs.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*		**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #33		☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Wood Post for MGS		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Lechtenberg, Holloway	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211047001	RPFP-11-MGS-3	7/1/10
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
12/31/13	12/31/13	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$157,655	$96,661	85

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,031	

Project Description:

The oversized blockout used with the MGS design is one reason that the guardrail has demonstrated a 100 percent increase in redirective capacity as compared to conventional guardrail systems. However, there are some locations where roadway width is insufficient to accommodate a 12-in. blockout. A number of proprietary adaptations of the MGS design have been developed that do not utilize a blockout, thereby providing more useable roadway in constricted sites. A non-blocked version of the MGS should be feasible for use in those locations with constricted roadway widths.

Objective: Develop a MASH version of the MGS without blockouts for standard steel posts using standard components. If modifications to the system such as post to rail attachment are deemed to be necessary, the new components should be able to replace the existing components for all new construction and repair applications. By changing the standard components in the supply chain, it should be possible to minimize the risk of utilizing the wrong components in a no blockout design.

Tasks:

1. Full-scale crash testing (MASH 3-10 and 3-11)
2. Analysis and documentation of test results
3. Research report
4. Hardware guide drawings and FHWA acceptance

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Review of the internal draft report was completed. The draft report was submitted to the Pooled Fund member states for review and comment.

Anticipated work next quarter:

Comments received from the Pooled Fund member states will be reviewed and implemented. The final report will be published and sent to the member states.

Significant Results:

On May 15, 2011, MwRSF conducted one pickup crash test (test no. MGSNB-1) into the Midwest Guardrail System (MGS) without blockouts using a 2270-kg Dodge QuadCab according to the TL-3 safety performance guidelines of MASH. The pickup was successfully contained and redirected.

On June 15, 2011, MwRSF conducted one small car test (test no. MGSNB-2) into the Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 MASH safety performance guidelines. Again, the small car was successfully contained and redirected.

Task	% Complete
1. Full-scale crash testing (MASH 3-10 and 3-11)	100%
2. Analysis and documentation of test results	100%
3. Research report	95%
4. Hardware guide drawings and FHWA acceptance	50%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

There are no problems or issues to report at this time.

Potential Implementation:

Narrow roadways will benefit from a non-proprietary non-blocked out system by making more roadway width available while still providing acceptable guardrail performance. Additionally, a non-proprietary alternative to the existing non-blocked out guardrails would eliminate problems associated with identifying and properly repairing proprietary 31-in. tall guardrail systems.

It should be noted that, even if the MGS is made to function without a blockout, the 12-in. block would still be recommended where there was adequate space existing along the roadside. The blockout greatly improves the barrier's capacity to contain and redirect high-energy impacts with high c.g. vehicles.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal, a percentage completion of each task, a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*		**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #34		☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Assess Standard Weld Detail		
Name of Project Manager(s): Reid, Sicking, Faller, Rosenbaugh	**Phone Number:** 402-472-9324	**E-Mail** srosenba@unlserve.unl.edu
Lead Agency Project ID: 2611211048001	**Other Project ID (i.e., contract #):** RPFP-11-MGS-4	**Project Start Date:** 7/1/2012
Original Project End Date: 12/31/2013	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$10,000	$10,000	90%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,181	

Project Description:

In 2001, the Midwest Roadside Safety Facility (MwRSF) successfully developed a guardrail connection for low-fill culverts according to the Test Level 3 (TL-3) safety performance guidelines found in NCHRP Report No. 350. After evaluating several base plates, bolts, and weld combinations with undesirable results, a final configuration was chosen which consisted of a ½-in. plate attached with a 5/16-in. three-pass fillet weld on the critical flange and a 1/4-in. fillet weld on the web and back-side flange. The final post design was successfully tested and evaluated using both dynamic component bogie testing and full-scale vehicle crash testing.

During the implementation of the W-beam guardrail system for attachment to concrete box culverts, various State Departments of Transportation have raised questions concerning the use of the three-pass fillet weld on the critical flange. As such, there exists a need to re-examine the use of the three-pass weld and determine whether a simplified alternative weld detail could be used in combination with the rigid post attachment.

Objectives / Tasks

1. Literature review of current practices
2. Design of new weld detail
3. Dynamic testing and analysis
4. Written Report containing design work, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, all four projected bogie tests (combined between this project and its related project TPF-5(193) Suppl. #47, RPFP-12 MGS 4) have been conducted and analyzed. Similar to the original study, the 3-pass weld was the only weld to hold the impact force without fracturing or tearing the base plate.

Work this quarter continued on the the report documenting all testing and conclusions. Currently, an internal draft has been completed and is in the process of being reviewed/edited. The report covers the results for both projects.

Anticipated work next quarter:

The internal draft report (covering both this project and the related TPF-5(193) Suppl. #47, RPFP-12 MGS 4) will be edited. The subsequent revision shall be sent to the Midwest Pooled Fund States for review.

Significant Results:

Two weld designs were selected via popular vote from the Pooled Fund members. Both weld designs were evaluated through a dynamic bogie impact test. During the tests the base plate tore adjacent to the weld on the front flange. During the component testing for the related project, TPF-5(193) Suppl. #47, RPFP-12 MGS 4, the 3-pass weld again illustrated is satisfactory performance even as the post and plate material strengths were increased from 36 ksi steel to 50 ksi steel.

Objectives / Tasks	% Completed
1. Literature review of current practices	100%
2. Design of new weld detail	100%
3. Dynamic testing and analysis	100%
4. Written Report containing design work, testing, and conclusions	80%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Although this project has no remaining funds, the report shall be finalized using the funds from the related project: TPF-5 (193) Suppl. #47, RPFP-12 MGS 4. The report will cover the testing and conclusions for both projects.

Potential Implementation:

The development of a simplified, standard weld detail will be compatible with the culvert-mounted, W-beam guardrail system and available for use on low-fill concrete box culverts.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin Department of Transportation

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #40	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Length of Need - B/C Analysis		
Name of Project Manager(s): Albuquerque, Sicking, Faller	**Phone Number:** 402-472-8600	**E-Mail** dbenicio@huskers.unl.edu
Lead Agency Project ID: 2611211060001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/2014	**Current Project End Date:** 6/30/2014	**Number of Extensions:**

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$113,499	$91,385	85%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$18,422	

Project Description:

Guardrail is used to shield motorists from collisions with roadside hazards and must extend long distances in advance of any roadside obstacle to minimize the risk of a vehicle traveling behind the barrier and striking the hazard. When the length of guardrail is increased, the risk that a vehicle will travel behind the barrier and strike the hazard is reduced. However, guardrail is also a roadside hazard that produces approximately 1,200 fatal crashes across the nation every year. Increasing the length of a guardrail installation increases the frequency of impacts with the barrier and thereby increases the risk of a serious crash. Further, the increase in barrier crash frequency associated with each incremental increase in guardrail length does not diminish as the guardrail is extended. At some point, the increase in the risk of serious injuries and fatalities associated with extending the guardrail outweighs the reduction in the risk of a vehicle traveling behind guardrail and producing serious injury or fatal impacts with the shielded hazard. Extending the guardrail beyond this optimal length will increase the overall risk that motorists will be involved in a serious injury or fatal crash.

The objective of this research effort is to quantify the probability of a vehicle traveling behind guardrail and striking a shielded hazard and its relationship to guardrail length. This probability will then be used to develop a revised procedure for determining optimal guardrail upstream length.

Objective / Task

1. Literature review
2. Guardrail, hazard and crash data collection
3. Data analysis
4. RSAP analysis
5. Written report containing all analysis and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

All RSAP analyses have been completed and documented.

Anticipated work next quarter:

The data analysis will be completed and documented. The draft report will be completed and submitted to Wisconsin DOT, the sponsoring agency.

Significant Results:

None

Objective / Task	% Complete
1. Literature review	100%
2. Data collection	100%
2. Accident data analysis	80%
3. RSAP analysis	100%
4. Written report containing all analysis and conclusions	75%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

The proposed research study would develop guardrail length design procedures calibrated to provide optimal safety for occupants of vehicles involved in ran-off-road crashes. These new procedures should provide both a reduction in the cost of guardrail construction and a reduction in the overall risk of motorist injury and fatality.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin Department of Transportation

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal, a percentage completion of each task, a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #41	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Crashworthy Pedestrian Rail		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211061001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/2014	**Current Project End Date:** 6/30/2014	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$234,629	$19,124	10%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$7,880	

Project Description:

Situations arise on the roadside where a barrier or rail is required to prevent pedestrians from crossing into a certain area which may be acceptable for an errant vehicle. Although these rails would not need to redirect or stop an errant vehicle, they must also not present additional hazards to the motoring public. These rails/fences should not cause excessive decelerations, vehicle snag points, vehicle instabilities, or produce fragments that may cause harm to other motorists when impacted. In addition, pedestrian rail systems must comply with the Americans with Disabilities Act (ADA). Therefore, a need may exist for a crashworthy pedestrian rail to protect pedestrians and prevent improper street crossings.

The objective of this research effort is development of a pedestrian rail to be ADA compliant and crashworthy. The objectives will be to identify the highest priority, crashworthy pedestrian rail need, to develop viable design concepts to meet that need, to finalize development of the crashworthy pedestrian rail system, and to perform the necessary MASH compliance tests for the system.

Objectives / Tasks

1. Literature review
2. Identification of rail needs and design criteria
3. Pedestrian rail design concepts
4. Component testing of design concepts
5. Summary report of design concepts
6. Finalize system details
7. Full-scale crash testing (MASH 2-91)
8. Full-scale crash testing (MASH 2-90)
9. Written report documenting design, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The highest priority need was determined from the surveys sent to the Pool Fund member states. This need was determined to be to prevent jaywalking across busy roadways. However, potential adaptation for culvert situations on the edge of the roadways was also to be considered.

The draft report with documentation of literature review findings continued.

Brainstorming of design concepts continued for material that met geometric requirements determined from the loading criteria. Rails placed in sections and long-spans are being considered as well as visibility through the rails.

Anticipated work next quarter:

Design concepts brainstorming and refinement will continue. Documenattion of the literature search results will continue.

Significant Results:

None

Objectives / Tasks	% Complete
1. Literature review	80%
2. Identification of rail needs and design criteria	95%
3. Pedestrian rail design concepts	60%
4. Component testing of design concepts	0%
5. Summary report of design concepts	25%
6. Finalize system details	0%
7. Full-scale crash testing (MASH 2-91)	0%
8. Full-scale crash testing (MASH 2-90)	0%
9. Written report documenting analysis, design, testing, and conclusions	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

The results from this research will provide a cost effective, ADA compliant, crashworthy, pedestrian rail that prevents foot traffic from crossing but does not pose as a hazard to errant vehicles.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin Department of Transportation

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #42		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Zone of Intrusion Concrete Barriers		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):** 2611211062001	**Project Start Date:** July 1, 2011
Original Project End Date: June 30, 2014	**Current Project End Date:** June 30, 2014	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$58,942	$48,080	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date

Project Description:

In 2010, MwRSF performed a ZOI study for the Florida DOT. That study investigated a 40-in. high, F-shape concrete barrier under NCHRP Report 350 TL-3 criteria. LS-DYNA was used to simulate a 2000P vehicle model impacting the barrier under several conditions. Those being (1) without any tire/suspension failure, (2) with suspension failure, and (3) with tire air out after initial impact.

WisDOT has had some previous discussions with MwRSF about working width for the single sloped barrier. Those discussions were not documented in any sort of report. Because most crash testing with concrete barriers have been performed with barrier heights of 32", there is little crash test data for taller barrier heights. Based on those discussions and lack of test data, WisDOT took a conservative approach to working width and ZOI. Basically, the approach was to assume that the ZOI and working width would be no greater than those determined for a 32" height barrier values as the barrier height increased.

The objective of this research is to either verify that the current ZOI and working width values are sufficient or to recommend updated values based on LS-DYNA simulation.

Objectives / Tasks
1. Literature review of ZOI values
2. LS-DYNA Simulation of 2270P impacts on single slope barriers
3. Written reports documenting all work and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Zone of Intrusion and working width values were evaluated for multiple impact conditions. It was determined that the impact conditions tested during the study were the most critical, realistic impact conditions that the current model could experience. A write-up of the results was conducted, and was submitted for internal review.

A model of a vehicle seat was obtained, and simulations were performed to evaluate its stability and dynamic performance. After approving the seat model, a model of an occupant was evaluated and placed in the seat to further evaluate the seat stability. A seat belt model was reviewed and selected. The belt model was placed across the simulated occupant's lap and shoulder, and the stability of the seatbelt model was determined. After determining an appropriate seatbelt model, the model was added into a full-scale crash to determine the model validity and to evaluate a simulated occupant placed in a vehicle.

The literature review report was edited and submitted for another internal draft.

Anticipated work next quarter:

Complete the internal reviews of the two reports, update appropriately and submit to WsDOT for review.

Significant Results:

Extensive database of information for the literature review has been developed.

Objectives / Tasks	% Complete
1. Literature review of ZOI values	95%
2. LS-DYNA Simulation of 2270P impacts on single slope barriers	100%
3. Written reports documenting all work and conclusions	70%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

none

Potential Implementation:

Information gained from this project will provide WisDOT a higher confidence level in their concrete barrier working widths and ZIO dimensions.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin Department of Transportation

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #43	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Roadside Grading Guidance - Phase II		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-6864	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: 2611211063001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/2014	**Current Project End Date:** 6/30/2014	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$199,502	$ 40,208	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$ 2,367	

Project Description:

Currently, it is difficult for designers to quantify the safety benefits of flattening roadway slopes. Consequently, a designer may not choose the most cost-effective roadside treatment for a given location. There are some tools to assist designers, however, these tools are difficult to use, time consuming, require training, and would be difficult to implement in a statewide policy. Therefore, there was a need to develop a tool (e.g. a series of graphs or charts) to help designers choose if flattening a slope for a given project is cost beneficial and, if so, identify the most appropriate method for providing slope flattening.

Previously, WisDOT funded a research study with the Midwest Roadside Safety Facility (MwRSF) to examine and update the severity values of roadside slopes, determine the range of slope conditions to be considered, and perform a benefit cost analysis to determine appropriate grading guidance. The total accident database contains approximately 20,000 accident cases, but the previous project analyzed only 1,500 of them due to budget limitations. The preliminary analysis of the data has only provided the average severity of slopes on rural arterials. These data cannot provide accurate correlation with speed limits and the depth of slope without expansion of the number of accident cases. It is believed that analysis of more accident data would allow determination of corresponding speed limits and slope depths. Thus, there is a need to expand this study with a second phase in order to improve the quality and accuracy of the slope grading guidance through analysis of as many of the available accident cases as possible.

Objectives / Tasks

1. Accident data collection
2. Data analysis and determination of critical elements
3. RSAP analysis
4. Written report documenting all analysis and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Of the two papers submitted to the 2013 Annual Transportation Research Board (TRB) Meeting, one was selected for presentation. Therefore, that paper was improved per recommendations made by external and internal reviewers and resubmitted to TRB.

Review of the internal draft report continued.

Anticipated work next quarter:

Internal review of the draft report is expected to be completed. As soon as the internal review is completed, the final report will be submitted to the sponsor agency.

In addition, a presentation detailing the process by which the severity index of embankments was determined for this project will be created. It will be presented at the 2013 Annual TRB meeting in lectern session 631.

Significant Results:

Objectives / Tasks	% Completed
1. Accident data collection	100%
2. Data analysis and determination of critical elements	100%
3. RSAP analysis	100%
4. Written report documenting all analysis and conclusions	80%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

none

Potential Implementation:

This research will provide designers with a tool that simplifies and expedites the process of designing roadside slope geometry. In addition, the guidelines developed herein will provide a uniform policy for roadside design throughout the state of Wisconsin, thus improving the consistency and safety of the roadside slope geometries in the state. Finally, this research should provide for more cost effective use of limited state highway funds by defining the most cost effective slope designs.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Midwest Roadside Safety Facility, UNL

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* SPR-3(017) Supplement #49		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: MGS Implementation (Year 18)		
Name of Project Manager(s): Reid, J.D., Sicking, D.L., & Faller, R.K.	**Phone Number:** 402-472-6864 (Faller)	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: RPFP-08-07 (2611120095008)	**Other Project ID (i.e., contract #):** SPR-3(017) Supplement #49	**Project Start Date:** September 1, 2007
Original Project End Date: December 31, 2009	**Current Project End Date:** December 31, 2012	**Number of Extensions:** 6

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$15,928 (original)	$12,312	77%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$1,281 (8%)	$1,281	77%

Project Description:

This project consists of MGS implementation assistance and guidance for the Pooled Fund member states. Four general categories were initiated for the MGS. They are as follows:

Task	% Completed
Standard, Half, and Quarter Post Spacing	100
MGS with Curbs and MGS with 2:1 Slopes	100
MGS with Culvert Applications	100
MGS Stiffness Transition	5

In 2007, Pooled Fund consulting funds were used to assist states with the MGS implementation effort. MwRSF began the effort with a review of CAD details from the Illinois and Washington DOTs. Project correspondence occurred via email with a pre-determined Technical Working group. To date, three subject areas were covered and are as follows: (1) Standard, Half, and Quarter Post Spacing; (2) MGS with Curbs and MGS on 2:1 Slopes; and (3) MGS with Culvert Applications. A fourth category, MGS Stiffness Transition, was delayed in order to await the completion of a simplified, steel-post and wood-post approach guardrail transition.

The final reporting of the simplified, steel-post, approach guardrail transition system attached to the MGS was completed in the Fourth Quarter of 2010. The final reporting of wood post R&D effort was completed in November 2011, including dynamic bogie post testing and Barrier VII analysis. The MGS implementation activities commenced in the 1st Quarter of 2012 with the updating of the discussion group members and request for MGS standards for each State DOT.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The MGS implementation activities commenced in the 4th Quarter of 2012. Technical review and support has been provided to the Ohio DOT in updating their MGS standard plans. Continued technical review and support was also provided to the Kansas DOT in updating their plans for the MGS attached to culverts. Once the Ohio DOT and Kansas DOT plans have been revised, MwRSF will acquire those updated MGS plans and share them with the Pooled Fund member states.

Further, many existing MGS R&D studies, such as those involving non-blocked MGS with steel posts and MGS with wood SYP posts, have been modified to include enhanced discussion and guidance on the implementation of the MGS in special applications.

Anticipated work next quarter:

As of November 30, 2012, approximately $12,312 of the $15,928 total project funds have been expended. It is expected that the remaining project funds in the amount of $3,616 will be utilized in December 2012 for continued MGS implementation activities. However, the MGS implementation efforts will continue into the First Quarter of 2013 and require the use of contingency funds.

Significant Results:

To date, MwRSF has provided review and comment regarding the MGS standard plans for Washington, Illinois, Kansas, Nebraska, and Ohio and for the first three categories and part of the fourth category. Since much of this effort began several years ago, the first three categories will be re-reviewed as many states are actively preparing and updating MGS details.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

As of November 30, 2012, approximately $12,312 of the $15,928 total project funds have been expended. It is expected that the remaining project funds in the amount of $3,616 will be utilized in December 2012 for continued MGS implementation activities. However, the MGS implementation efforts will continue into the First Quarter of 2013 and require the use of contingency funds.

Potential Implementation:

MwRSF's review and comment has assisted several State DOTs with the advance implementation of the MGS and its design variations.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #19	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)

Project Title:

Phase II - Guidelines for Post-Socketed Foundations for 4-Cable, High-Tension, Barrier System

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Rosenbaugh	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211026001	RPFP-10-CABLE-1	7/1/2009
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/2012	4/30/2013	1

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule ☑ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$92,207	$11,319	35%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$41	

Project Description:

This project is the second Phase of a project which was undertaken the year previous - split up due to available funds in previous year not being sufficient to cover entire project.

High-tension cable barriers often incorporate socketed post foundations to simplify repair of the system after an accident. Barrier posts are designed to slide in and out of a ground socket for easy replacement of damaged components. Unfortunately, there have been numerous examples of socketed post foundations that are damaged during a cable barrier crash. In most cases, socket damage requires repair crews to either replace the socket itself or drive a post directly into the soil adjacent to the damaged component. Either situation defeats the purpose of using sockets and greatly increases the time necessary to restore a damaged barrier. The increased repair time translates into higher maintenance costs and increased risk to repair crews working adjacent to high-speed facilities.

Many existing socketed post foundation designs are constructed by drilling a hole in the soil, placing a steel sleeve in the hole, and backfilling with Portland cement concrete. Many of these designs do not have sufficient reinforcement to resist impact loads that are transmitted into the socket. Further, many of the sockets are too short to resist frost heave that can push the posts out of the ground. Thus, there is a need for general design guidelines that states can incorporate to assure that socketed post foundations perform as intended when used in the field.

Objectives/Tasks:

1. Design new socket foundations for barrier posts.
2. Fabrication and dynamic testing of socketed foundations.
3. Analysis of test data and evaluation of socketed foundation designs.
4. Written report documenting all work and conclusions.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, dynamic bogie testing was conducted on concrete foundations in stiff soil (AASHTO grade B). The 12" diameter concrete foundations continued to see damage in the form of large concrete pieces breaking free from the top - back side of the foundation during testing. From these tests, 36 inches appears to be the minimum embedment depth to limit deflections. Additionally, work has continued on the report documenting all testing and conclusions.

Recently, the posts to be used in the new, non-proprietary, cable median barrier have been switched from an S3x5.7 to a bent plate, channel shaped post. Work on the foundation design has been waiting for the design of these new posts to be finalized before further testing will take place.

Anticipated work next quarter:

Upon the selection of a new post for use in the new, non-proprietary, cable median barrier system, the foundation design will be re-evaluated and redesigned. The new posts are to be significantly weaker that the previous S3x5.7 posts, so the existing socketed foundation design may get smaller and/or have reduced internal steel.

Additionally, a critical mow strip design will be selected for evaluation with the socketed post foundations. The foundation design may be modified to reflect the increase in confinement strength that the mow strip will provide. New designs will be dynamically tested to evaluate performance.

Significant Results:

Phase I of this project included the evaluation of 4 new socketed foundation designs. All 4 of these first round designs experienced heavy damage in the form of concrete fracture and plastic deformation of the reinforcing steel. As a result, 4 new reinforcement designs were configured to provide additional strength to the socketed foundation.

Round 2 of testing saw four foundations designs evaluated in sand. Although concrete shear failure occurred in all designs, the 60" embedment proved adequate to resist rotation in weak/saturated/sandy soils.

Round 3 of testing determined 36 was the required embedment depth for 12" diameter foundations placed in strong soil (AASHTO Grade B).

Objectives/Tasks:	% Completed (Phase II)
1. Design new socket foundations for barrier posts.	40%
2. Fabrication and dynamic testing of socketed foundations.	40%
3. Analysis of test data and evaluation of socketed foundation designs.	30%
4. Written report documenting all work and conclusions.	20%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Additional (matching) funds for Phase-I of this project were obtained through a Mid-America Transportation Center program. This matching funding was used during the first round of design, testing, and evaluation for the socketed foundations. Thus, some of the original Phase-I funding remains as it was not used until the MATC funding was depleted. As a result, the continuing work which would have been conducted under Phase II of the project is being charged to the Phase I project until the funds are gone. Limited time has been charged to the Phase II project to date, but the test charges from Round 2 of testing have been placed on this project's budget.

This project was originally set to close on July 31, 2012. However, the additional funding obtained for Phase-I of the project has resulted in remaining funds in the Phase-I project and nearly all of the funds remaining for Phase-II. Therefore, an extension was granted extending the closing date to 4/30/2013.

Potential Implementation:

Upon successful completion of this project, State DOT's will have the option to use a socketed post foundation for cable barrier system posts. The socketed foundation will allow for quick, easy, and inexpensive repairs to damaged sections of the barrier.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #31	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Wood Post for MGS		
Name of Project Manager(s): Reid, Sicking, Faller, Lechtenberg, Bielenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211045001	**Other Project ID (i.e., contract #):** RPFP-11-MGS-1	**Project Start Date:** 7/1/10
Original Project End Date: 12/31/13	**Current Project End Date:** 12/31/13	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$121,215	$86,028	75

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,435	

Project Description:

Although the Federal Highway Administration has approved the use of the MGS with both W6x9 steel and 6x8-in. wood posts, no rectangular standard southern yellow pine post designs have been subjected to full-scale crash testing according to the MASH criteria. Eventually this testing needs to be conducted to verify the MGS performance with the most common wood post used in the United States.

Objective: Verify that 6x8-in. southern yellow pine wood post option for MGS has similar characteristics to the steel post MGS.

Tasks:

1. Full-scale crash testing (MASH 3-10 and 3-11)
2. Analysis and documentation of test results
3. Research report
4. Hardware guide drawings and FHWA acceptance

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Review of the internal draft report continued.

Anticipated work next quarter:

Review of the internal draft report will be completed. The draft report will be submitted to the Pooled Fund member states for review and comment.

Significant Results:

On August 3, 2011, MwRSF conducted one pickup crash test (test no. MGSSYP-1) into a 31-in. tall Midwest Guardrail System (MGS) with standard southern yellow pine wood posts using a 2270-kg Dodge QuadCab according to the TL-3 safety performance guidelines of MASH. The pickup was successfully contained and redirected.

On September 13, 2011, MwRSF conducted one small car test (test no. MGSSYP-2) into a 32-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 MASH safety performance guidelines. Again, the small car was successfully contained and redirected.

Task	% Complete
1. Full-scale crash testing (MASH 3-10 and 3-11)	100%
2. Analysis and documentation of test results	100%
3. Research report	85%
4. Hardware guide drawings and FHWA acceptance	50%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

The same test pit was used for Project No.:RPFP-11-MGS-3 – TPF-5(193) Supplement #33, Project Title: MGS without Blockouts. The wood post MGS system was constructed and tested following the completion of the aforementioned project. However, there are no additional problems or issues to report at this time.

Potential Implementation:

Full-scale crash testing and verification of the safety performance of the southern yellow pine post MGS system will provide designers with increased confidence when specifying a rectangular wood post option for the MGS. In addition, specifying wood posts can be a less costly alternative to steel posts in some areas, and wood posts may provide for a more aesthetic treatment.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #44		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211064001	**Other Project ID (i.e., contract #):** RPFP-12-CABLE1&2	**Project Start Date:** 7/1/11
Original Project End Date: 6/30/14	**Current Project End Date:** 6/30/14	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$233,262	$165,161 (+$100,449 from Yr 21 Co	65

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$42,368 (+$25,084 from Yr 21 Cont.)	

Project Description:

This project is an extension to previous projects (RPFP-08-02: Four-Cable Median Barrier in 4:1 V-Ditch; RPFP-09-01: New Funding for High-Tension Cable Barrier on Level Terrain with New Cable Attachment; and RPFP-10-CABLE-2: Replacement Funding for High-Tension Cable Barrier on Level Terrain).

Original Objective: To complete the development, testing, and evaluation of the four-cable, high-tension, median barrier system for use in 4H:1V sloped medians.

Revised Objective: To complete the development, testing, and evaluation of the four-cable, high-tension, median barrier system placed 0 to 4 ft away from the slope break point of a 6H:1V sloped medians.

Tasks:

1. Full-scale crash testing (MASH 3-10)
2. Full-scale crash testing (MASH 3-11)
3. Full-scale crash testing (Additional MASH 1500A)
4. Analysis and documentation of test results
5. Research report (s)
6. Hardware guide drawings and FHWA acceptance

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The text of what was done this quarter extends further than what is shown. Click within the box and scroll down.

Review of the internal draft report of test no. 4CMBLT-1 was completed. The draft report was submitted to the Pooled Fund member states for review and comment on October 26, 2012.

The two different designs of the one-piece, tabbed brackets (which are an alternative design to the keyway bolts) were continuing to be investigated. The second alternative design were bolted tabbed brackets and were tested in test nos. HTTB-9 through HTTB-16. They behaved in a way which was similar to the keyway bolts because, like the keyway bolts, they were relatively fixed at the bottom where they were bolted to the jig. Both the 10-gauge and the 11-gauge versions exhibited some scraping against the inside of the flange as they were pulled vertically, but not to the extent as seen with the crimp-in-place designs. Both versions fractured through the top tab when pulled laterally. The 10-gauge bolted tabbed bracket had vertical and lateral release loads of 0.94 kips and 4.57 kips, respectively. The 11-gauge bolted tabbed bracket had vertical and lateral release loads of 0.78 kips and 5.18 kips, respectively.

Design modifications of the bolted tabbed bracket design were investigated. The new designs aimed to further reduce the vertical release loads by extending the distance between the inside of the flange and the part of the top tab which rubs against it. The new designs were being fabricated.

The straight brass rod concept for the top cable attachment was selected to be dynamically component tested. This dynamic test was conducted in mid-November.

The new folded C-channel post made from sheet steel were fabricated from two different sheet thicknesses. Sixteen

Anticipated work next quarter:

Comments receive from the Pooled Fund member states will be reviewed and implemented into the research report of 4CMBLT-1. The final report will be published and disseminated to the Pooled Fund member states.

The top cable attachment dynamic component testing will be analyzed, evaluated, and documented.

The dynamic component testing of the new folded C-channel post made from sheet steel will be analyzed.

The new designs for the bolted tabbed bracket design will will be investigated through dynamic component testing as done with the previous designs. However, if the new post section shows promising results, the new bolted tabbed bracket design will be tested with this post section.

An update meeting with the Pooled Fund member states will be scheduled for the next quarter after the results of the above mentioned component testing has been completed.

A report will be initiated that will include the component tests conducted on the tabbed bracket and keyway bolt designs, the top cable attachment concepts and design, and the folded C-channel posts.

Significant Results:

As the result of the guidance from the member States in August 2011, it was decided the four-cable barrier system would be developed for use on sloped medians as steep as 6H:1V instead of 4H:1V but still placed 0 to 4 ft away from the slope break point (Plan B from letter dated August 15, 2011).

Task	% Complete
1. Full-scale crash testing (MASH 3-10)	0%
2. Full-scale crash testing (MASH 3-11) - 4CMB-5	100%
3. Full-scale crash testing (Additional MASH 1500A) - 4CMBLT-1	100%
4. Analysis and documentation of test results - 4CMB-5	100%
5. Analysis and documentation of test results - 4CMBLT-1	100%
6. Analysis and documentation of test results (MASH 3-10)	0%
7. Research report - 4CMB-4 and 4CMB-5	100%
8. Research report - 4CMBLT-1	95%
9. Research report	0%
10. Research report - Vehicle Trajectory Analysis	100%
11. Hardware guide drawings and FHWA acceptance	0%
12. Redesign of system	70%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This project is an extension to previous projects (RPFP-08-02: Four-Cable Median Barrier in 4:1 V-Ditch; RPFP-09-01: New Funding for High-Tension Cable Barrier on Level Terrain with New Cable Attachment; and RPFP-10-CABLE-2: Replacement Funding for High-Tension Cable Barrier on Level Terrain).

It should be noted that the test conducted with the 1500A on the system placed on level terrain (Test No. 4CMBLT-1 conducted on June 14, 2011) was charged to the Project No.:RPFP 11 CONT TPF 5(103) Supplement #30, Project Title: Pooled Fund Year 21 Contingency even though it was one of the tests funded in Project No.:RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-Ditch. At the time this test was conducted, Year 22 funds were not available for use. The funds in the above mentioned contingency funds were available and were to be used to fund part of Phase II of this project.

As the result of the guidance from the member States in August 2011, it was decided the four-cable barrier system would be developed for use on sloped medians as steep as 6H:1V but still placed 0 to 4 ft away from the slope break point (Plan B from letter dated August 15, 2011). Depending on the simulation results and future modifications to the proposed MASH test matrices, up to seven full-scale crash tests may be required, including three level terrain tests.

Recall the development work was not originally a part of the current budget. Therefore, funds for the redesign work are being utilized from both this project as well as Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #45, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, Level Terrain since the redesign will apply to both the V-ditch and level terrain scenarios.

Potential Implementation:

The successful completion of the development, testing, and evaluation of the Midwest four-cable, high-tension, median barrier in sloped medians will allow the member states to implement a non-proprietary, high-tension, cable system along our nation's highways and roadways. The successful completion of this project along with the non-proprietary four-cable, high-tension, median barrier on level terrain and cable guardrail end terminal would help to assure acceptance by FHWA and improve its chances for widespread implementation.

Summary of Modified Keyway Bolts and Tabbed Brackets

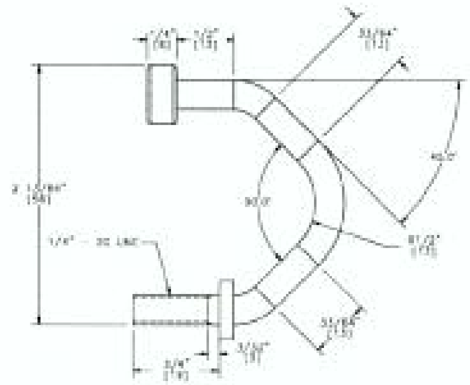
Significant effort has been undertaken to improve the cable clip and post designs for the 4-cable high-tension median barrier. New cable clips were conceptualized in design meetings and tested in component tests. The component tests measure the force required to release a cable from the post to which it is attached under dynamic loading conditions. The simple setup includes a bogie, a length of cable, the cable clip, and a test jig with a load cell, as shown in Figure 1. The test jig is shown in Figure 2.

Figure 1. Bogie Test Setup

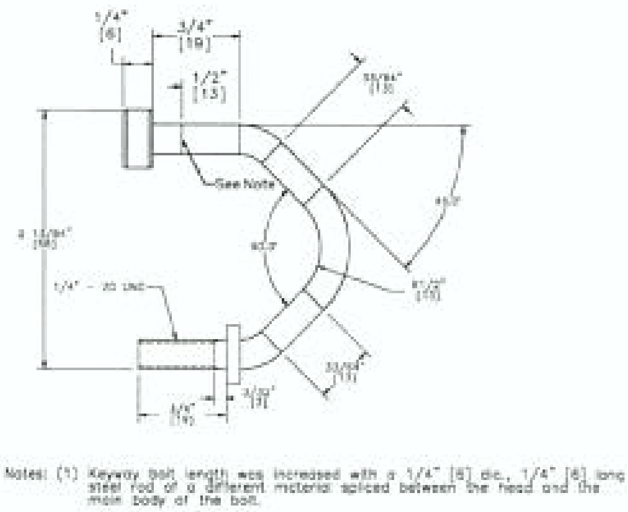
Figure 2. Close-up of Test Jig

The jig can be adjusted so that the cable pulls on the clip in a direction parallel to the post to which it is attached (testing the vertical release strength) or perpendicular to the post to which it is attached (testing the lateral release strength). The cable clips from the previous full-scale crash tests had vertical and lateral releases of 1.2 kips and 8 kips, respectively. As part of the redesign effort, it was decided that the vertical release strength of the new cable clips needed to be lower. The first new concepts that were tested were modified keyway bolts. A total of 28 bogie tests were performed on these concepts and are summarized in Table 1.

The final design from this test series was a keyway bolt made of a slightly weaker steel (AISI C1018 rather than ASTM A449), with a ¼-in. extension on the end of the shaft to allow the bolt to rotate up and out of the keyhole without scraping against the inside of the flange of the post when pulled vertically. The new keyway bolt design is shown in Figure 3. For the test series, the prototypes of the extended keyway bolts were fabricated by cutting and splicing a ¼-in. extension into the shaft. If selected as the final design, the extended keyway bolts would be fabricated from one continuous round bar, without splices.



"Old" Keyway Bolt



"New" Keyway Bolt

Figure 3. Keyway Bolt with ¼-in. Extension

Table 1. Modified Keyway Bolt Test Results Summary

Test	Orientation	Test Article	Material	Keyhole	Release Load (kip)	Result
HTCUB-38	Vertical	Keyway Bolt	ASTM A449	Small Oversized	0.494	Free release through keyhole, button snag
HTCUB-39	Vertical	Keyway Bolt	ASTM A449	Small Oversized	0.459	Free release through keyhole, button snag
HTCUB-40	Vertical	Keyway Bolt	ASTM A449	Large Oversized	0.489	Free release through keyhole, button snag
HTCUB-41	Vertical	Keyway Bolt	ASTM A449	Large Oversized	0.415	Free release through keyhole, button snag
HTCUB-42	Vertical	Keyway Bolt	AISI C1018	Small Oversized	0.305	Free release through keyhole, button snag
HTCUB-43	Vertical	Keyway Bolt	AISI C1018	Small Oversized	0.39	Free release through keyhole, button snag
HTCUB-44	Vertical	Keyway Bolt	AISI C1018	Large Oversized	0.282	Free release through keyhole, button snag
HTCUB-45	Vertical	Keyway Bolt	AISI C1018	Large Oversized	0.379	Free release through keyhole, button snag
HTCUB-46	Lateral	Keyway Bolt	ASTM A449	Small Oversized	0.636	Free release through keyhole, button snag
HTCUB-47	Lateral	Keyway Bolt	ASTM A449	Small Oversized		Button caught on flange, release through keyhole
HTCUB-48	Lateral	Keyway Bolt	ASTM A449	Large Oversized	0.642	Free release through keyhole, button snag
HTCUB-49	Lateral	Keyway Bolt	ASTM A449	Large Oversized	0.542	Free release through keyhole, button snag
HTCUB-50	Lateral	Keyway Bolt	AISI C1018	Small Oversized	0.381	Free release through keyhole, button snag
HTCUB-51	Lateral	Keyway Bolt	AISI C1018	Small Oversized	0.39	Free release through keyhole, button snag
HTCUB-52	Lateral	Keyway Bolt	AISI C1018	Large Oversized	0.483	Free release through keyhole, button snag

HTCUB-53	Lateral	Keyway Bolt	AISI C1018	Large Oversized	0.944	Free release through keyhole, button snag
HTCUB-54	Lateral	Modified Keyway Bolt	AISI C1018	Large Oversized	2.9	Button caught on flange, release through keyhole
HTCUB-55	Lateral	Modified Keyway Bolt	AISI C1018	Large Oversized	0.798	Free release through keyhole, smaller button snag
HTCUB-56	Vertical	Modified Keyway Bolt	AISI C1018	Large Oversized	1.71	Button rubbed on flange as it released, smaller button snag
HTCUB-57	Vertical	Modified Keyway Bolt	AISI C1018	Large Oversized	1.17	Button rubbed on flange as it released, smaller button snag
HTCUB-58	Vertical	Keyway Bolt with 1/4-in. Extension	AISI C1018	Original dual-width	0.455	Free release through keyhole, smaller button snag
HTCUB-59	Vertical	Keyway Bolt with 1/4-in. Extension	AISI C1018	Original dual-width	0.44	Free release through keyhole, smaller button snag
HTCUB-60	Lateral	Keyway Bolt with 1/4-in. Extension	AISI C1018	Original dual-width	3.53	Button caught on flange, released through keyway
HTCUB-61	Lateral	Keyway Bolt with 1/4-in. Extension	AISI C1018	Original dual-width	1.75	Button caught on flange, released through keyway
HTCUB-62	Lateral	Keyway Bolt with 1/4-in. Extension	AISI C1018	Modified dual-width	5.71	Button caught on flange, fracture through weld of extension
HTCUB-63	Lateral	Keyway Bolt with 1/4-in. Extension	AISI C1018	Modified dual-width	4.62	Button caught on flange, fracture through weld of extension
HTCUB-64	Vertical	Keyway Bolt with 1/4-in. Extension	AISI C1018	Modified dual-width	0.585	Free release through keyhole, smaller button snag, crack in weld
HTCUB-65	Vertical	Keyway Bolt with 1/4-in. Extension	AISI C1018	Modified dual-width	0.442	Free release through keyhole, smaller button snag, crack in weld

Modified keyway bolts were not the only designs tested. However, the knowledge gained during the modified keyway bolt tests was applied to the subsequent designs. The idea of a clip and keyhole was carried over into the subsequent designs because it is a good way to control the lateral and vertical release strengths independently. The first of the new concepts, shown in Figure 4, was a one-piece tabbed bracket that could be crimped into place in a keyhole. One of the main advantages of a tabbed bracket, made of sheet steel rather than round bar, is that the cross-section can be more easily modified. This is critical because cross-sectional properties like the area and plastic modulus control the fracture and bending behavior of the cable clips. In theory, the width or thickness of the cross-section of the tabbed brackets could be adjusted to essentially tune the vertical and lateral release strengths. The major disadvantage, and the reason the crimp-in-place brackets were not further pursued, was the inability to control scraping against the inside of the flange as the cable clip was pulled vertically.

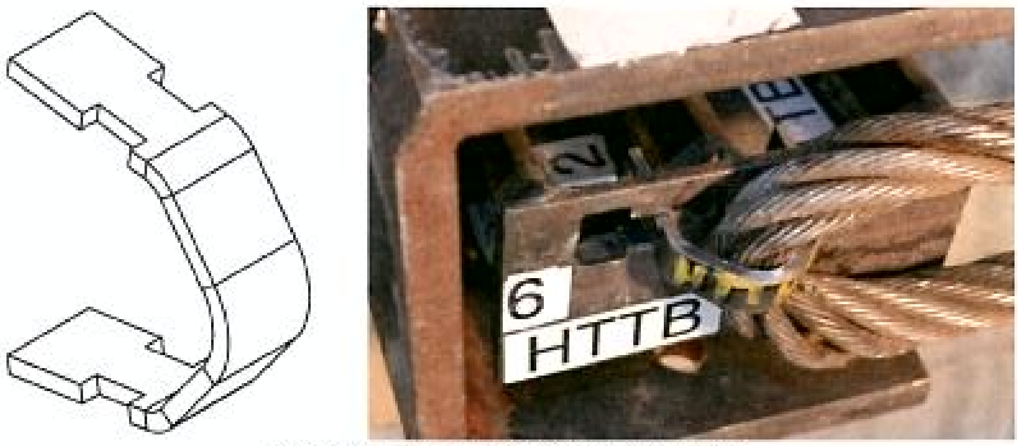


Figure 4. Crimp-In-Place Tabbed Bracket

In order to mitigate scraping against the inside of the flange for the tabbed bracket concepts, a bolt was added to fix the bottom of the clip to the post. The neck of the bracket that sat in the narrow part of the top keyhole was also extended, to varying degrees, in order to allow for free rotation out of the keyhole. The resulting bolted tabbed bracket concept is shown in Figure 5. This concept is still in testing, but based on past experience with the modified keyway bolts, there is confidence that this will result in a final design with desirable vertical and lateral release strengths. The results from the tabbed bracket tests conducted are summarized in Table 2

Figure 5. Bolted Tabbed Bracket

Table 2. Tabbed Bracket Tests Results Summary

Test No.	Orientation	Test Article	Gauge	Material	Result	Peak Load
HTTB-1	Lateral	Crimp-In-Place Tabbed Bracket, Version 1	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracture through the neck of the bottom tab	5.87 kips (26.1 kN)
HTTB-2	Lateral	Crimp-In-Place Tabbed Bracket, Version 1	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracture through the neck of the bottom tab	5.99 kips (26.6 kN)
HTTB-3	Lateral	Crimp-In-Place Tabbed Bracket, Version 2	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracture through the neck of the bottom tab	6.40 kips (28.5 kN)
HTTB-4	Lateral	Crimp-In-Place Tabbed Bracket, Version 2	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracture through the neck of the bottom tab	6.71 kips (29.8 kN)
HTTB-5	Vertical	Crimp-In-Place Tabbed Bracket, Version 1	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Release through keyhole, high loads suggest tab scraping along inside of flange	2.87 kips (12.8 kN)
HTTB-6	Vertical	Crimp-In-Place Tabbed Bracket, Version 1	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Release through keyhole, high loads suggest tab scraping along inside of flange	2.80 kips (12.5 kN)
HTTB-7	Vertical	Crimp-In-Place Tabbed Bracket, Version 2	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Release through keyhole, high loads suggest tab scraping along inside of flange	1.43 kips (6.36 kN)
HTTB-8	Vertical	Crimp-In-Place Tabbed Bracket, Version 2	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Release through keyhole, high loads suggest tab scraping along inside of flange	1.20 kips (5.34 kN)
HTTB-9	Vertical	Bolted Tabbed Bracket, Version 3	11	Hot-Rolled ASTM A1011 HSLA Grade 50	No load cell data, Top tab scraped along the inside of the flange before releasing through keyhole	NA
HTTB-9R	Vertical	Bolted Tabbed Bracket, Version 3	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Top tab scraped along the inside of the flange before releasing through the keyhole	0.790 kips (3.51 kN)
HTTB-10	Vertical	Bolted Tabbed Bracket, Version 3	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Top tab scraped along the inside of the flange before releasing through the keyhole	0.760 kips (3.38 kN)

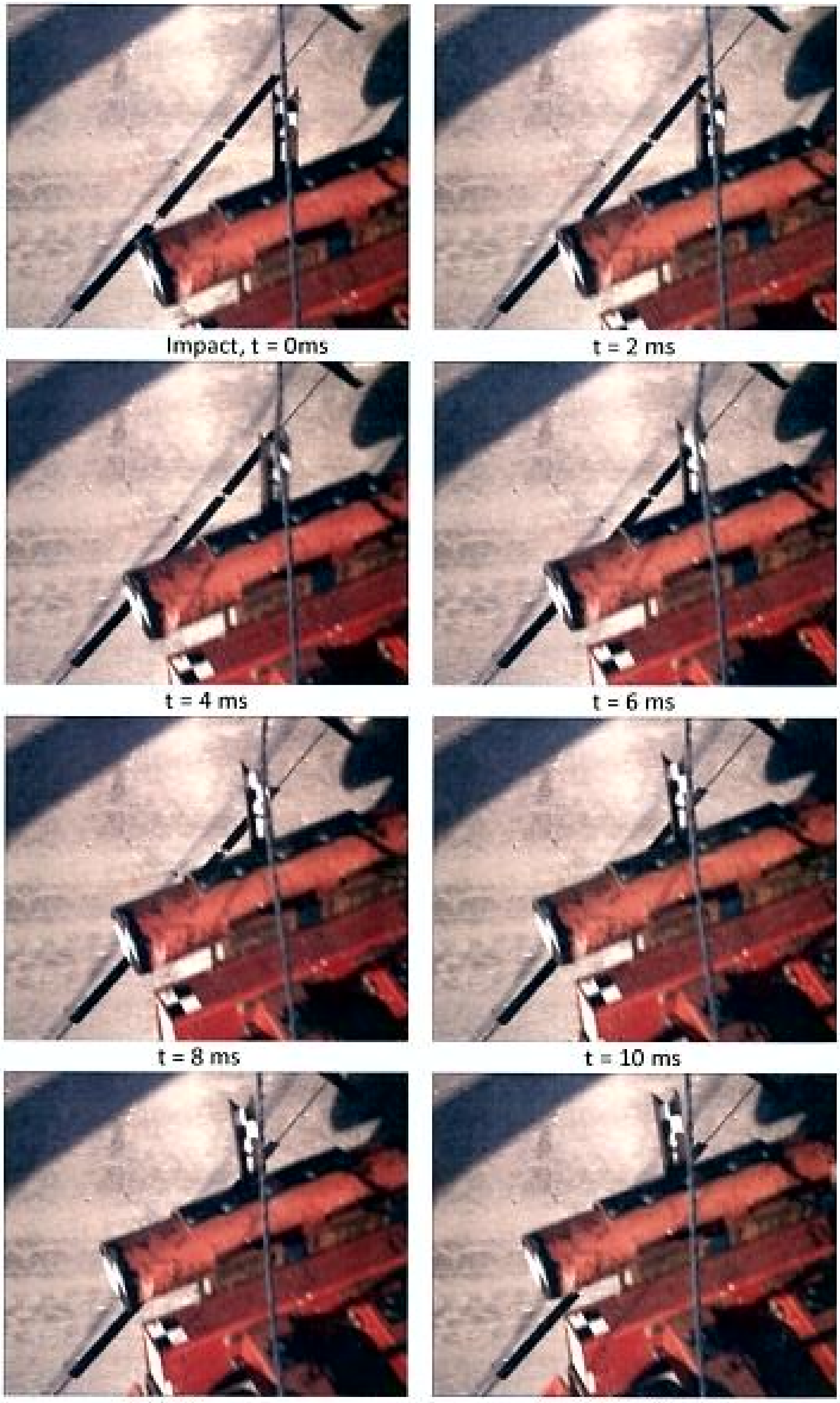
HTTB-11	Lateral	Bolted Tabbed Bracket, Version 3	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracture through the neck of the top tab	5.14 kips (22.9 kN)
HTTB-12	Lateral	Bolted Tabbed Bracket, Version 3	11	Hot-Rolled ASTM A1011 HSLA Grade 50	No high-speed video, Caught in the slot initially, but slipped out, no fracture	2.38 kips (10.6 kN)
HTTB-12R	Lateral	Bolted Tabbed Bracket, Version 3-MC	11	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracure through the neck of the top tab	5.21 kips (23.2 kN)
HTTB-13	Vertical	Bolted Tabbed Bracket, Version 4-MC	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Top tab scraped along the inside of the flange before releasing through the keyhole	0.899 kips (4.00 kN)
HTTB-14	Vertical	Bolted Tabbed Bracket, Version 4-MC	10	Hot-Rolled ASTM A1011 HSLA Grade 50	No high-speed video, Top tab scraped along the inside of the flange before releasing through keyhole	0.989 kips (4.40 kN)
HTTB-15	Lateral	Bolted Tabbed Bracket, Version 4-MC	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracure through the neck of the top tab	4.45 kips (19.8 kN)
HTTB-16	Lateral	Bolted Tabbed Bracket, Version 4-MC	10	Hot-Rolled ASTM A1011 HSLA Grade 50	Fracure through the neck of the top tab	4.69 kips (20.9 kN)

Top Cable Clip Concepts

The modified keyway bolts and tabbed brackets were designed for use on the bottom three cable clips, but the top cable clips were to be designed differently. Based on vehicle override of the system in test no. 4CMB-5, due in part to the failure of the top cable to release from the post at the point of impact, the new top cable clips were to be designed to release almost effortlessly. Their new function would be just to keep the cable attached to the post before an impact. The design of these concepts started from scratch. Many designs were conceptualized and then tested via a static vertical pull test in order to get an idea of how much strength they had. Most concepts tested were a variation of a brass or stainless steel rod, bent, and made to fit into holes at the top of the post. A total of 65 static pull tests were performed on these very simple concepts. The final concept was a straight, brass rod as shown in Figure 6 with the static test jig.

Figure 6. Straight Rod Top Cable Clip

After the static pull tests were completed, the most promising concept was chosen to be used in a dynamic component test in order to test whether or not the straight rod would release the cable when the post to which the cable was attached was struck by a vehicle. A simplified, 5-post, cable barrier with only one cable (the top one) was set up, and a bogie vehicle impacted the middle post at a speed of 45 mph and at an angle of 25 degree. Sequential photos of the dynamic component test are shown in Figure 7. The clip performed as it was designed, releasing the cable at the impacted post, but retaining the cable at the adjacent posts. There was no significant downward cable deflection before the clip released the cable, indicating that in an actual impact, the cable would not be pulled to the ground with the post, as was evident in full scale crash test no. 4CMB-5. The straight brass rod will be used in future full scale crash tests.



Impact, t = 0ms | t = 2 ms | t = 4 ms | t = 6 ms | t = 8 ms | t = 10 ms | t = 12 ms | t = 14 ms, Release

Figure 7. Sequential Photographs of Top Cable Dynamic Component Test

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal, a percentage completion of each task, a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #45	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase II		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211065001	**Other Project ID (i.e., contract #):** RPFP-12-CABLE1&2	**Project Start Date:** 7/1/11
Original Project End Date: 6/30/14	**Current Project End Date:** 6/30/14	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$91,800 (+$91,089 from Yr 21 contingency)	$4,189 (+$100,449 from Yr 21 Cont.)	0

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$4,189 (+$25,084 from Yr 21 Cont.)	

Project Description:

The Midwest Roadside Safety Facility (MwRSF) has been conducting research for the Midwest States Regional Pooled Fund Program to develop a non-proprietary, high-tension, four-cable, median barrier that is capable of being used anywhere in a V-ditch with 4H:1V side slopes. Three tests still remain to complete the test matrix of the cable barrier system in a V-ditch. In addition, the four-cable, high-tension, median barrier has never been tested on level terrain. There is a concern that FHWA may not approve this design without testing on flat ground, especially when considering the wide cable spacing and increased cable heights. Further, the barrier deflections observed in crash tests performed in a 4H:1V V-ditch are likely higher than would be observed on flat ground. Crash testing of the barrier installed on level terrain would identify barrier deflections and working widths that can be expected when the barrier is used in narrow medians with gentle slopes and would allow for better performance comparisons between the Midwest four-cable barrier and other proprietary systems.

Objective: To complete the development, testing, and evaluation of the four-cable, high-tension, median barrier system for use on level terrain.

Tasks:

1. Full-scale crash testing (MASH 3-10 and 3-11)
2. Analysis and documentation of test results
3. BARRIER VII calibration and analysis for alternate configurations
4. Research report
5. Hardware guide drawings and FHWA acceptance

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

None

Priorities set by the Pooled Fund member States are for the continued development of a high-tension, cable barrier system for relatively-flat and sloped median applications was to focus on the four-cable barrier system for use on sloped medians as steep as 6:1 but still placed 0 to 4 ft away from the slope break point.

Recall development work was not originally a part of this current budget nor that of Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-ditch Therefore, funds for the redesign work are being utilized from both this project as well as Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-ditch since the redesign will apply to both the V-ditch and level terrain scenarios.

See Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-ditch for a detailed explanation of the work completed.

Anticipated work next quarter:

None.

Priorities set by the Pooled Fund member States are for the continued development of a high-tension, cable barrier system for relatively-flat and sloped median applications was to focus on the four-cable barrier system for use on sloped medians as steep as 6:1 but still placed 0 to 4 ft away from the slope break point.

Significant Results:

Task	% Complete
1. Full-scale crash testing (MASH 3-10 and 3-11)	0%
2. Analysis and documentation of test results	0%
3. BARRIER VII calibration and analysis for alternate configurations	0%
4. Research report	0%
5. Hardware guide drawings and FHWA acceptance	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

A portion of this project ($91,089 is not included in the project budget shown on page 1) will be funded with Project No.: RPFP-11-CONT – TPF-5(193) Supplement #39, Project Title: Pooled Fund Year 21 Contingency.

It should be noted that the test conducted with the 1500A on the system placed on level terrain (Test No. 4CMBLT-1 conducted on June 14, 2011) was charged to the above mentioned contingency funds even though it was one of the tests funded in Project No.:RPFP 12 CABLE1&2 TPF 5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-Ditch. At the time this test was conducted, Year 22 funds were not available for use. The funds in the above mentioned contingency funds were available and were to be used to fund part of this project (Phase II).

As the result of the guidance from the member States in August 2011, it was decided the four-cable barrier system would be developed for use on sloped medians as steep as 6:1 but still placed 0 to 4 ft away from the slope break point (Plan B from letter dated August 15, 2011). Depending on the simulation results and future modifications to the proposed MASH test matrices, up to seven full-scale crash tests may be required, including three level terrain tests.

Recall development work was not originally a part of this current budget nor that of Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-ditch Therefore, funds for the redesign work are being utilized from both this project as well as Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-ditch since the redesign will apply to both the V-ditch and level terrain scenarios.

Potential Implementation:

The successful completion of the development, testing, and evaluation of the Midwest four-cable, high-tension, median barrier on level terrain will allow the member states to implement a non-proprietary, high-tension, cable system along our nation's highways and roadways. In addition, the crash testing of the four-cable, high-tension, median barrier on level terrain would also provide a more complete understanding of barrier performance (i.e., dynamic deflections, working width, etc.) when used in relatively flat, narrow medians. The crash results from the level terrain testing will be used in combination with computer simulation to evaluate the effects of reduced post spacing. The successful completion of this project along with the non-proprietary four-cable, high-tension, median barrier in V-ditch and cable guardrail end terminal would help to assure acceptance by FHWA and improve its chances for widespread implementation.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*		**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #47		☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: MGS Culvert Attachment with Epoxied Rods		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Rosenbaugh	**Phone Number:** 402-472-9324	**E-Mail** srosenba@unlserve.unl.edu
Lead Agency Project ID: 2611211067001	**Other Project ID (i.e., contract #):** RPFP-11-MGS-4	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/2014	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$19,935	$11,292	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,138	

Project Description:

MwRSF has previously developed a TL-3 guardrail system for use on low-fill culverts and according to the NCHRP Report No. 350 safety performance criteria. In this application, the steel guardrail posts were anchored to the top of the culvert slab using through bolts in combination with a base plate that is welded to the bottom of the posts. However, problems can arise when the guardrail post coincides with the location of a vertical support wall found inside the culvert. For this scenario, through bolts cannot be utilized to anchor the guardrail posts to the culvert slab since there is unavailable space to place the lower bearing plate or access the lower end of the through bolt. Instead, it is necessary to use an alternative anchorage option, such as a threaded rod anchored into the culvert slab and upper region of the vertical wall. Unfortunately, no design recommendations exist for using epoxied anchor rods to attach the steel posts to the top of the culvert slab. A small research study is needed to evaluate suitable epoxied anchor rods for use with the W-beam guardrail over culvert system.

In 2010, the Midwest Pooled Fund States funded a small project to determine an alternative, standard weld detail which simplifies the post-plate attachment for the guardrail system mentioned above and to evaluate the new weld detail through both analysis and bogie testing. The proposed project herein is to act as a supplement to the current project, RFPF-11-MGS-4.

Objectives / Tasks

1. Literature review
2. Design of epoxied anchors
3. Dynamic testing and analysis of design
4. Written report containing all design, analysis and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, the bogie testing portion of this project (2 tests) was completed. 6 inches of embedment caused the threaded rods to pull out of the concrete. 8 inches of embedment provided adequate strength throughout the impact.

This quarter, work has continued on the report documenting all testing, analysis, and conclusions for this project. The testing report includes work form another project (TPF-5(193) suppl. #34) as they both deal with attachment of the top mounted culvert post to culvert slabs. An internal draft report has been completed and is currently under internal review.

Anticipated work next quarter:

The internal draft report (covering both this project and the related TPF-5(193) Suppl. #34, RPFP-11 MGS-4) will be edited. The subsequent revision shall be sent to the Midwest Pooled Fund States for review.

Significant Results:

The first dynamic bogie impact test conducted on a post assembly anchored by rods embedded 6" into the tarmac resulted in the anchors pulling out of the concrete. The second test was conducted on a post utilizing an 8" embedment depth. During the second test, both the anchors and the post-to-plate weld held and the post was plastically deformed. Thus, 8 inches of embedment will be required for proper attachment of the top-mounted culvert post in locations where epoxy anchors are desired over the original bolt-through design.

Objectives / Tasks	% Completed
1. Literature review	100%
2. Design of epoxied anchors	100%
3. Dynamic testing and analysis of design	100%
4. Written report containing all design, analysis and conclusions	80%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Potential Implementation:

The development of an epoxied anchor rod alternative to the original through bolt anchorage of the culvert guardrail posts will allow the system to be installed anywhere across the top slab of the concrete culvert, regardless of the location of interior, culvert walls.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task, a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #48	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Pooled Fund Center for Highway Safety		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211068001	**Other Project ID (i.e., contract #):** RPFP-12-PFCHS-1	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/14	**Current Project End Date:** 6/30/14	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$24,859.00	$529.00	15%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$134.00	

Project Description:

Many of MwRSF's inquiries from members of the Midwest States Pooled Fund program can be answered based upon prior pooled fund or other research. Further, even though answers to pooled fund inquiries are normally routed to all pooled fund states in the quarterly progress report, there are numerous repeat questions every year. The quarterly summaries are helpful to member states, but they are temporary and not well organized by the type of question or specific topic. Many pooled fund inquiries could be answered through the development of a Center of Highway Safety web site. This web site would provide an organized and searchable summary for all State inquiries and MwRSF reports as well as CAD details pertaining to Pooled Fund crash tested systems. This safety center would also be helpful to non-member states with problems or inquiries similar to those identified by the member states.

A dedicated and well-maintained Pooled Fund Center for Highway Safety web site would provide for all of these needs. It would provide for a searchable database of previous MwRSF inquiries and solutions, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features. Through MwRSF's relationship with the Nebraska Transportation Center (NTC), experienced personnel can be hired to perform website design, programming, as well as provide reliable website hosting facilities. However, the development, maintenance, operation, and hosting of the web site will require funding. It is anticipated that the costs to develop, operate, maintain, and host a Pooled Fund Center for Highway Safety web site would be $24,859.00 in funding for FY 22.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The MwRSF Pooled Fund Consulting web site is fully functional and MwRSF has begun work on the Pooled Fund Center for Highway Safety web site. MwRSF has met with web site developers at UNL and have begun plans for a web site that will house all of the MwRSF research reports and CAD details in a searchable format for downloading. It is anticipated that the web site will tie in with both the existing MwRSF web site and the recently finished MwRSF Pooled Fund Consulting web site. The web site is in its development phase.

MwRSF has met with the web site development team and determined the site design and organization, the search functionality, and the materials to archive on the site.

During this quarter, the web site development team at UNL and has developed a the user interface and database framework for the Pooled Fund Center for Highway Safety web site. MwRSF will meet with the development team at the end of the Fourth Quarter to review and troubleshoot the web site. MwRSF will begin to archive materials to the website beginning in the First quarter of 2013.

Anticipated work next quarter:

MwRSF plans to populate the web site archive during the first quarter of 2013 and have the site full functional and available to the Midwest Pooled Fund member states by the end of the first quarter of 2013.

Again, at this time, the existing funds for the project should allow for archiving of MwRSF research reports and CAD details.

Significant Results:

None.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The Pooled Fund Center for Highway Safety web site would provide immediate access to a wide library of roadside safety materials for designers and engineers, including reports, CAD details, etc. It would also provide a searchable database of previous solutions and responses to prior Pooled Fund inquiries and problems. The web site would also be available through controlled access to state DOT's around the country which would promote improved roadside safety.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #48		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Pooled Fund Center for Highway Safety		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211086001	**Other Project ID (i.e., contract #):** RPFP-13-PFCHS	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/14	**Current Project End Date:** 6/30/14	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$10,958.00	$0.00	0%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$0.00	

Project Description:

Many of MwRSF's inquiries from members of the Midwest States Pooled Fund program can be answered based upon prior pooled fund or other research. Further, even though answers to pooled fund inquiries are normally routed to all pooled fund states in the quarterly progress report, there are numerous repeat questions every year. The quarterly summaries are helpful to member states, but they are temporary and not well organized by the type of question or specific topic. Many pooled fund inquiries could be answered through the development of a Center of Highway Safety web site. A dedicated and well-maintained Pooled Fund Center for Highway Safety web site would provide for all of these needs. It would provide for a searchable database of previous MwRSF inquiries and solutions, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features. This safety center would also be helpful to non-member states with problems or inquiries similar to those identified by the member states.

In Year 22, the Midwest States Pooled Fund states sponsored the development of a Pooled Fund Center for Highway Safety web site. This project allowed for the development of the first phase of the web site and archiving of materials on the web site. In the past year, a web site for the Midwest States Pooled Fund consulting questions and responses was developed and made available. The web site is currently operational and provides functions for submitting questions and inquiries to MwRSF as well as posting of the responses. It also provides a searchable database of previous MwRSF inquiries and solutions. The website is located at http://mwrsf-qa.unl.edu/.

In addition to the consulting web site, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features has been started. MwRSF is currently in the process of making this web site operational and uploading the archived reports and CAD. MwRSF anticipates that this archive will be fully functional in the near term. The report and CAD archive as well as the Midwest States Pooled Fund consulting web site will be integrated with the main MwRSF web site in the near future as well.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

At this time, the Pooled Fund Center for Highway Safety web site is still under development and the funding provided in this project has yet to be accessed for web maintenance and updating.

Anticipated work next quarter:

The project funding herein will not be accessed until the Pooled Fund Center for Highway Safety web site is full operational. It is anticipated that the web site will be functional in the first quarter of 2013.

Significant Results:

None.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The Pooled Fund Center for Highway Safety web site would provide immediate access to a wide library of roadside safety materials for designers and engineers, including reports, CAD details, etc. It would also provide a searchable database of previous solutions and responses to prior Pooled Fund inquiries and problems. The web site would also be available through controlled access to state DOT's around the country which would promote improved roadside safety.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #49	**Transportation Pooled Fund Program - Report Period:** ☐ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☑ Quarter 4 (October 4 – December 31)

Project Title:

Annual Fee to Finish TF-13 and FHWA Standard Plans

Name of Project Manager(s): Reid, Sicking, Faller, Lechtenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211069001	**Other Project ID (i.e., contract #):** RPFP-12-TF13	**Project Start Date:** 7/1/11
Original Project End Date: 6/30/14	**Current Project End Date:** 6/30/14	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$3,983	$3,983	75

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$481	

Project Description:

Each year, the Midwest States Pooled Fund program sponsors several roadside safety studies at the Midwest Roadside Safety Facility (MwRSF) of the University of Nebraska-Lincoln. Some of these research efforts result in the development of new roadside safety features. As part of this effort and on behalf of the member states, MwRSF seeks FHWA acceptance for those devices or systems meeting current impact safety standards. In the future, FHWA will require standard Task Force (TF) 13-format CAD details along the typical system details when requests for hardware acceptance are made.

MwRSF prepares 2-D and/or 3-D CAD details for newly developed roadside safety features that are subjected to full-scale vehicle crash testing. The CAD details used to describe the as-tested systems or components are not always prepared and presented in the same format as now required by AASHTO TF 13 and FHWA. As such, additional CAD details and background information must be prepared when FHWA acceptance is sought under MASH or when the new system or associated components are submitted for inclusion in the electronic version of the barrier hardware guide.

Objective: For all new barrier hardware, the member states request that MwRSF seek formal FHWA acceptance and placement of standardized TF-13 CAD details in the electronic version of the highway barrier guide. This funding shall be used to supplement the preparation of the TF-13 format CAD details.

Tasks:

1. Prepare CAD details for Hardware Guide

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Updated drawings based on comments received at the AASHTO TF-13 Spring meeting held in April 2012 and Fall meeting held in October 2012.

All funds for this project have been exhausted during this quarter. All further work will be conducted under Project No. RPFP-13-TF13 - TPF-5(193) Supplement #53, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans.

Anticipated work next quarter:

None.

The funds have been expended and the project was closed.

Significant Results:

This project is used to supplement the preparation of the TF-13 format CAD details. Previously, it was determined that there are 14 systems and 11 components that need to be prepared in the TF-13 format. During discussions with the AASHTO TF-13 subcommittee in July 2011, new components had to be generated from the existing system drawings. Thus, the original 11 components became 32. Two of the systems and one component had limited work that need to be completed on the drawings as they were to be included in the Bridge Rail Guide and Luminaire Guide, respectively.

In evaluating the separation of the components, it was determined that some could be combined into one drawing based on the same type of component, but just one varying parameter.

Summary of Barrier Guide individual drawings to date:
31 systems - 25 approved, 6 to be reviewed
41 components - 15 approved, 26 to be reviewed
2 systems submitted to Bridge Rail Guide
1 component submitted to Luminaire Guide

Task	% Complete
1. Prepare CAD details for Hardware Guide	100%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Funding from Project No.: RPFP-11-TF-13 – TPF-5(193) Supplement #38, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans used prior to starting this project.

At the present time, standard TF13-format CAD details are now required and subjected to review and comment by TF 13 members. This review is taking place during the TF-13 meetings which occur twice a year. After the initial review, the drawings are edited and then reviewed again at a later meeting. Once the CAD details are deemed acceptable and meet TF 13 guidelines, they are integrated into the electronic, web-based, version of the existing barrier hardware guide. Consequently, it requires a minimum of 6 months to get a drawing accepted for inclusion in the hardware guide; that is if there are only minimal edits to be made to the drawing. Sometimes, TF-13 requires a second review and more edits, thus adding another 6 months on to the time for its acceptance. For example, five (5) of the 13 systems were submitted for review during the September 2010 meeting. However, the allotted time only allowed the review of three (3) of the systems. The other two (2) were reviewed during the May 2011 meeting. Thus, some drawings may be in the review state at TF-13 for over a year before they are even looked at for the first time.

TF-13 is in the process of developing an online review system which will expedite the review process and allow more systems to be reviewed prior to their semi-annual meetings. Then at the TF-13 meetings it will be a final review and vote on if the drawings are ready to be implemented into the online guide.

Potential Implementation:

Newly-developed highway safety hardware will be contained in the electronic, web-based guide, thus promoting the standardization of barrier hardware across the U.S. and abroad.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #53	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)	
Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans		
Name of Project Manager(s): Reid, Sicking, Faller, Lechtenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211079001	**Other Project ID (i.e., contract #):** RPFP-13-TF13	**Project Start Date:** 7/1/12
Original Project End Date: 6/30/15	**Current Project End Date:** 6/30/15	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$3,983	$80	0

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$80	

Project Description:

Each year, the Midwest States Pooled Fund program sponsors several roadside safety studies at the Midwest Roadside Safety Facility (MwRSF) of the University of Nebraska-Lincoln. Some of these research efforts result in the development of new roadside safety features. As part of this effort and on behalf of the member states, MwRSF seeks FHWA acceptance for those devices or systems meeting current impact safety standards. In the future, FHWA will require standard Task Force (TF) 13-format CAD details along the typical system details when requests for hardware acceptance are made.

MwRSF prepares 2 D and/or 3 D CAD details for newly developed roadside safety features that are subjected to full-scale vehicle crash testing. The CAD details used to describe the as-tested systems or components are not always prepared and presented in the same format as now required by AASHTO TF 13 and FHWA. As such, additional CAD details and background information must be prepared when FHWA acceptance is sought under MASH or when the new system or associated components are submitted for inclusion in the electronic version of the barrier hardware guide.

Objective: For all new barrier hardware, the member states request that MwRSF seek formal FHWA acceptance and placement of standardized TF-13 CAD details in the electronic version of the highway barrier guide. This funding shall be used to supplement the preparation of the TF-13 format CAD details.

Tasks:

1. Prepare CAD details for Hardware Guide

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Updated drawings based on comments received at the AASHTO TF-13 Spring meeting held in April 2012 and Fall meeting held in October 2012.

Anticipated work next quarter:

Continue to update drawings based on comments received at the AASHTO TF-13 Spring meeting held in April 2012 and Fall meeting held in October 2012.

Significant Results:

This project is used to supplement the preparation of the TF-13 format CAD details. Previously, it was determined that there are 14 systems and 11 components that need to be prepared in the TF-13 format. During discussions with the AASHTO TF-13 subcommittee in July 2011, new components had to be generated from the existing system drawings. Thus, the original 11 components became 32. Two of the systems and one component had limited work that need to be completed on the drawings as they were to be included in the Bridge Rail Guide and Luminaire Guide, respectively.

In evaluating the separation of the components, it was determined that some could be combined into one drawing based on the same type of component, but just one varying parameter.

Summary of Barrier Guide individual drawings to date:
31 systems - 25 approved, 6 to be reviewed
41 components - 15 approved, 26 to be reviewed
2 systems submitted to Bridge Rail Guide
1 component submitted to Luminaire Guide

Task	% Complete
1. Prepare CAD details for Hardware Guide	50%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Funding from Project No.: RPFP-12-TF-13 – TPF-5(193) Supplement #49, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans used prior to starting this project.

TF-13 is in the process of developing an online review system which will expedite the review process and allow more systems to be reviewed prior to their semi-annual meetings. Then at the TF-13 meetings it will be a final review and vote on if the drawings are ready to be implemented into the online guide.

Potential Implementation:

Newly-developed highway safety hardware will be contained in the electronic, web-based guide, thus promoting the standardization of barrier hardware across the U.S. and abroad.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #54		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Annual Consulting Services Support		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211080001	**Other Project ID (i.e., contract #):** RPFP-13-CONSULT	**Project Start Date:** 7/1/2012
Original Project End Date: 6/30/15	**Current Project End Date:** 6/30/15	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$39,992.00	$17,375.00	50%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$16,595.00	

Project Description:

This project allows MwRSF to be a valuable resource for answering questions with regard to roadside safety issues. MwRSF researchers and engineers are able to respond to issues and questions posed by the sponsors during the year. Major issues discussed with the States have been documented in our Quarterly Progress Reports and all questions and support will now be accessible on a MwRSF Pooled Fund Consulting web site.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

In the past quarter MwRSF has responded to a series of state inquiries. The Quarterly Progress Report summarizing these responses has been attached to this document. The summary does not include all of the items answered through the consulting project over the last 6 months due to a backlog of questions and answers that were created during the time the site was down (see previous progress reports). This backlog must be entered manually. Approximately 1/3 of the backlogged questions were uploaded during this quarter and more will be input over time. Questions submitted directly to the web site during the last quarter are included. The summary will also be available for download at the recently completed MwRSF Pooled Fund Consulting web site - http://mwrsf-qa.unl.edu/

All of the previous issues with security and functionality of the MwRSF Pooled Fund Consulting web site were resolved this quarter and the web site is once again fully functional. We would ask that all Pooled Fund member states use the new site from this point forward for their inquiries.

Anticipated work next quarter:

MwRSF will continue to answer questions and provide support to the sponsors during the upcoming quarter.

We would ask that all questions be submitted through the web site so that they can be answered and archived therein.

http://mwrsf-qa.unl.edu/

Significant Results:

A quarterly summary of the consulting effort was provided and users can use the web site to search and find responses as well.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

None.

Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

07-01-2012 to 12-12-2012

Median Barrier Anchoring Options

Question

State: IA
Date: 06-22-2012

We have a project on I-80 coming up where we will be installing the "head ejection" median barrier. I am requesting your assistance in developing a few options for anchoring the barrier into existing pavement.

As shown in the attached PDF, the barrier will be installed on three slightly different median pavement configurations. In all cases, the existing unreinforced PCC slab is 10 feet wide and 12 inches thick. Note that the barrier may shift left or right within the slab, but should not get any closer than 1 foot from the edge of the slab.

It would be preferable to use the same (or very similar) anchoring details for all three configurations. The final pavement elevation must match existing.

Please let me know if you have any questions.

Thanks!

Response

Date: 06-25-2012
Dr. Faller has asked me to help you with the anchoring of the TL-5 median barrier to an existing concrete slab. From your comments below, I'm assuming that you are wanting to dowel/epoxy into the existing median slab and not use the asphalt keyway of the original (as tested) design. If so, this could be accomplished in a couple of different ways: 1) the stirrups could be modified to be open at the bottom, extended in length, and placed into the slab - this option would resemble the stirrups used in the end section configuration. 2) The stirrups could remain the same and #5 dowel bars would be placed at 18" intervals to match up with and anchor the

stirrups. Note - the #4 dowel bars shown in the original report and design drawings for the TL-5 median barrier were used to anchor the rebar cage during casting. These bars were not considered in the strength analysis of the barrier.

Let me know if either of these two options sounds like what you had envisioned... or if I'm completely off base.

Attachment: http://mwrsf-qa.unl.edu/attachments/03bb2a03f747ff9093b2b8d53d1d396f.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/03bb2a03f747ff9093b2b8d53d1d396f.pdf

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Response
Date: 06-25-2012
You got it. Either of those options (or some version of those options) would be much more agreeable to us instead of removing a bunch of concrete and pouring a new, separate footer. And you're right - we are not interested in using the asphalt keyway on this project.

Do I need to pick between the two options, or were you planning on evaluating both of them?

Response
Date: 06-25-2012
The two options are directly related since they would both include utilizing epoxy to anchor #5 bars to the slab (same spacing/intervals too). Thus, the embedment depth and location of the holes/anchors would be identical. As such, I can sketch up both options and you can choose between the two based on cost and constructability.

For both options, the spacing would always remain consistent at 18 inches - both front and back sides of the barrier. However, the embedment depth would be a function of the epoxy strength and concrete strength. You would have to use the manufacturers technical manual / recommendations on embedment to obtain full capacity of the rebar. Does Iowa have a preferred epoxy, or is this open?

Recently, MwRSF has been utilizing the HIT-RE 500 epoxy from Hilti (1,800 psi bond strength) for our anchorage designs. This product coupled with a concrete f'c of 4,000 psi would require only 6 inches of embedment to ensure full capacity of a #5 bar.

Also, are you planning on casting the barrier with the 1/18 face slope or with a vertical face (design option discussed in report). I only ask because if the 1/18 slope is being utilized, the dowels will be bent to match the slope of the stirrups - anchoring at an angle is usually not desired.

Response

Date: 06-25-2012

I would be interested in seeing a sketch of both options. This would be extremely helpful when used to explain the options to others.

I'm not sure that we have a preferred epoxy, but we do have a list of approved sources. I found the following passage in ourMaterials IM 491.11. Appendix C is the only place I found a listing for Hilti RE-500. Can you take a look and see if these are the types of systems we should be employing in this situation, or if we should limit the systems listed in Appendix C, or if we should provide a separate list of approved sources for this particular project?

Appendix Ccontains polymer grouts for dowel bar installation. Either an encapsulated chemical

anchor system or a pressure-injectable system with mechanical proportioning and mixing shall be

required to blend the material to uniform consistency.

To obtain approval for products under Appendix C, the laboratory evaluation will consist of bonding

a No. 5 reinforcing bar in a 4-inch deep 3/4-inch diameter hole in a concrete specimen and

performing a pullout load test. The test specimen shall develop a 40-pound minimum pullout load in

one hour and a 24-hour pullout load at a minimum of 10,000 pounds. The specimen will be kept at

laboratory temperature. Two specimens are needed to obtain the average of each pullout load.

Products meeting the requirements for Appendix C will also be placed on Appendixes A and B.

Manufacturers whose products require special equipment such as an injection or mixing equipment shall recommend which equipment can be used with their product.

We are planning on having the barrier slipformed, so we will probably be using the 1/18 slope on the barrier face. Would this require an additional bend in the stirrups in order to avoid drilling/anchoring at an angle?

Response

Date: 06-26-2012

Please the attached PDFs for the two epoxy anchorage options previously discussed. Please note that the embedment dimension of 6" is based on Hilte's HIT-RE 500 epoxy (bond strength of 1,800 psi). If another epoxy is desired, then the embedment depth may need to be altered to ensure ultimate tensile capacity can be obtained. Also, this epoxy anchorage retrofit design assumes the concrete slab that you are anchoring too has sufficient size and strength as to prevent movement, rotation, and damage to the slab. In your case of a 10 ft by 12 in deep slab, this should not be an issue.

Option 1 is divided into an Option 1a and 1b. 1a keeps the stirrup angled to follow the barrier before being bent to vertical 2 inches from the base of the barrier. 1b has the sides of the stirrup being bent to vertical near the top of the barrier, thus eliminating the need for the small bend near the base.

For Option 2, I recommend doweling in using straight bars during the epoxy/anchoring stage, letting the epoxy set, and then bending the tops of the dowels inward to match and tie to the angled sides of the barrier stirrups. Stirrups would remain identical to original design.

Option 1 will save on material cost as the amount of steel is reduced, but Option 2, may be easier to construct during installation

Attachment: http://mwrsf-qa.unl.edu/attachments/dbbee6f4ab38455e17de61da7e5c5fb1.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/dbbee6f4ab38455e17de61da7e5c5fb1.pdf

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Response

Date: 07-05-2012

Does anything change if we will be using epoxy-coated rebar for the cage and the dowels?

Response

Date: 07-05-2012

In a recent study on epoxy anchors, MwRSF did dynamic testing on both black rebar and epoxy coated rebar dowels. The testing has been completed, but the report is still being put together. Bob is the one finishing the report, so he would know the conclusions of this study better than I. Unfortunately, he is out of the office until next week. From my recollection, I believe there is a 5-10 percent decrease in anchorage strength expected for epoxy coated bars. If this is correct, then the embedment depth would need to be extended slightly (1/2" to 1") in order to ensure full capacity of the rebar can be developed.

The Hilti design manual lists an embedment depth of 5Â¾" is required to obtain ultimate capacity of a #5 bar - I rounded this up to 6" to be a little conservative and to get a nice even number. The Hilti manual does not mention anything for the effects of epoxy coated rebar. Thus, if my above statements are correct (Bob help me out here) then the embedment depth should be increased to minimum of 6.5".

Don't take any of this as accurate until Bob confirms this...

Response
Date: 07-05-2012

Scott is correct that our recent dynamic testing of epoxy coated rods with chemical adhesives showed approximately a 10% reduction when compared to black steel. Thus the increased embedment of 6.5" indicated by Scott is warranted and should provide the necessary strength.

Response
Date: 07-08-2012

The other point of concern I had was with the splice length required between the cage and the dowels being epoxied into the pavement - whether using epoxy-coated bars increases the required lap length.

Response
Date: 07-16-2012
The required lap splice length for an epoxy coated #5 bar according to the ACI Code is 28 in. The original sketches I sent you showed 30" long dowels embedded 6 inches into the slab and extended 24 inches into the barrier (for uncoated rebar). Using 6.5 inches of embedment and extending 28 inches into the barrier, epoxy coated dowels would need to be 35 inches in length.

Connection of a sound wall to a concrete barrier

Question

State: WI
Date: 07-12-2012

Below is a drawing connecting a sound wall to a concrete barrier.

From my understanding is that our structures department has reviewed this and are satisfied with the structural design.

Could the L4x4x3/4 bracket that sits on top of the parapet be a snag point?

Attachment: http://mwrsf-qa.unl.edu/attachments/0703468b6187202ac340607e9b3ea429.pdf

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Response

Date: 07-12-2012

I have briefly reviewed the 2 pages of details for a new noise wall system. You noted that there exists a 4"x4"x3/4" steel angle on top of the concrete parapet and welded to a vertical W10x22 steel support post. No information was provided regarding the noise panel material, size, or its attachment to the steel posts. You inquired as to the propensity for vehicles to snag on the small angle bracket.

42" Concrete Parapets

For 42" tall concrete parapets, the risk of 2000P and 2270P vehicle snag via engine hood and front quarter panel may be somewhat limited. However, the risk of vehicle snag with 8000S and 10000S single-unit trucks may be increased and depend on the structural strength and integrity of the sound panel material and its attachment to the steel posts.

32" Concrete Parapets

For 32" tall concrete parapets, the risk of 2000P and 2270P vehicle snag via engine hood and front quarter panel on the angle bracket and support posts will likely be increased over that observed for 42" tall barriers and depend on the structural strength and integrity of the sound panel material and its attachment to the steel posts.

It should be noted that we are unable to determine the crashworthiness of this noise barrier system by simply reviewing the provided schematics. The more appropriate means for evaluating the safety performance of roadside hardware is to conduct full-scale crash testing. Let me know if you have any additional questions or comments. Thanks!

Reasonable Variance of Cable Barrier Placement

Question

State: MO
Date: 07-13-2012

I am requesting your concurrence on a reasonable variance in the lateral placement of a cable barrier system.

Here's the problem:

We are currently under construction of a 10-mile segment of high-tension (Gibraltar) cable barrier in the median of I-55 in Jefferson County, MO. As a first item of work the 3-in. thick by 6-ft. HMA vegetative barrier has been placed throughout the project limits. The subsequent work generally consists of auguring 12-in. holes and pouring the concrete sockets.

On this particular project, when an inspector went to provide a line for the contractor to bore holes, he realized that a 2009 resurfacing project had incorrectly striped a 13-ft. passing lane at the expense of half a foot of driving lane and half a foot of shoulder. So now we are left with the situation I've depicted below, wherein, on average, there is a 3.6-ft. inside shoulder.

We realize that there is a documented 8.6-ft. dynamic deflection when a pickup impacts the Gibraltar system, so a backside hit on our 7.6 offset would result in a 1-ft. intrusion into the lane. Of course this is an undesirable situation, so we set about looking for an appropriate remedial option.

The following is a truncated list of potential solutions, along with the primary reason they're infeasible.

Option 1 - Install the barrier 0.5 ft. further down the 6:1 inslope. This is undesirable because the sizeable rocks being augured out of the socket holes are tearing out chunks of the HMA mat currently and a location closer to the edge only compounds this problem. The project budget cannot tolerate additional costs associated with repairing damage to the mat.

Option 2 - Lower deflections by decreasing post spacing. The project budget cannot tolerate this increased cost and the 50% increase in posts and sockets would compound the previously mentioned problem of damaging the HMA mat.

Option 3 - Fog-seal the existing rumble-stripe and restripe the passing lane to the correct width. This option is undesirable because fogging a line with oil only partially obscures it. In fact on rainy days, at night, and in certain sunlight conditions, the covered line is still visible and confusing to the driver. Given the thin lift (NovaChip) layer upon which the stripe is painted, milling off the stripe is out of the question.

Option 4 - Use a driven (steel sleeve) socket 0.5 ft. further down slope. Over 50% of the posts locations are in heavy rock fill where it is impossible to drive a sleeve. If a pilot hole were to be augured, the same problem identified in Option 1 would present itself.

Option 5 - Stockpile the cable barrier system for installation after the striping is corrected with the next overlay. This option is undesirable because MoDOT wishes to start realizing the safety benefit immediately, not in 3 to 4 years.

After exploring as many as 6 additional remedial options, a do-nothing approach (with respect to lateral placement) seems to have merit. The reasoning is based on the low likelihood that a vehicle would be crowding the rumble-stripe on a 13-ft. lane, and the fact that this corridor is eligible for resurfacing in as little as three years, at which time the geometry of the pavement markings would be corrected and a new rumble strip milled.

So here's the question:

Would a 7.6-ft. available deflection distance be considered a reasonable variance in the lateral placement of the three-strand Gibraltar system on a 6:1 slope?

I look forward to your prompt response.

Attachment: http://mwrsf-qa.unl.edu/attachments/93044e89b7e3c6f243a5943811e22e86.gif

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Response

Date: 07-18-2012

With all things considered and your reasons for being unable to make significant changes, you may have to utilize the proposed layout. I know that you understand that there exists approximately 1 ft of anticipated encroachment into the adjacent lane during extreme impact events with passenger vehicles (based on crash test data only). This additional encroachment could result a very slight increase in risk for partial vehicle contact with a very, very small portion of oncoming traffic, although the majority of the vehicles would not typically be traveling in the outer 1 ft of the traveled lane. Second, we do not believe that this proposed placement would significantly degrade barrier performance below that provided by the same barrier system installed 1 ft farther away from the lane edge.

Let me know if you want to further discuss via phone.

Response

Date: 07-20-2012

The below request has been reviewed and commented upon by both the FHWA Office of Safety in Washington D.C., and the Midwest Roadside Safety Facility (MwRSF) at the University of Nebraska. Both of these offices are authorities in the roadside safety field and their prompt, thoughtful responses are appreciated. In both cases, the do nothing approach (Option 10) was shown to be a reasonably safe, albeit less than ideal solution for the cable barrier placement issues on Jefferson I-55. Their comments are summarized below:

- The FHWA stated that as long as this particular segment of I-55 showed no inordinately high level of crossover accidents from the northbound toward the southbound direction (backside hits), then the 9 other options explored and rejected were "adequate justification for the status quo." The accident history has been reviewed and the rate of crossover accidents is at a normal level.

- The MwRSF also cited the 9 infeasible options explored as justification for installing the barrier as designed. They did note that a "very slight" increase in incidental contact could be apparent in a backside hit, although "the majority of the vehicles would not typically be traveling in the outer 1 ft of the traveled lane."

If either of these positions have been misrepresented, please advise.

A subsequent conversation with the FHWA Missouri Division Office gave verbal approval to a design exception proposing Option 10 as a temporary solution until the pavement markings can be corrected with the next resurfacing project.

In light of all this, I recommend that the cable barrier be installed as shown on the plans and the pavement markings, along with the rumble strips, be corrected with the next pavement resurfacing. If you find this solution reasonable, please work with the SE district liaison to draft and seek approval of a design exception.

Nested vs 12 gauge thrie beam

Question

State: IA
Date: 06-26-2012

When it comes to approach guardrail transitions, is nested 12-gauge thrie-beam considered equivalent to a single 10-gauge thrie-beam (and vice-versa)? How about nested w-beam?

Response

Date: 07-13-2012

Nested 12-gauge thrie beam would provide greater overall bending and tensile strength than that provided by a single 10-gauge thrie beam. Most crash tests on thrie beam bridge railing and approach guardrail transition systems likely have utilized nested 12-gauge thrie when additional strength was needed or desired. However, MwRSF has conducted limited crash testing on thrie beam bridge railing and approach guardrail transitions where only one single 10-gauge thrie beam was utilized. Historically, many of us have been comfortable with allowing both thrie beam alternatives (i.e., nested 12-gauge T and single 10-gauge T) in situations where additional strength has been desired. Some of the complaints often pertain to the need to stock and differentiate between 10 and 12 gauge thrie beam sections. However, others may not necessarily hold the same opinion.

With regards to W-beam sections, nested 12-gauge beams would once again be stronger than a single 10-gauge beam in terms of bending and tensile capacity. To date, MwRSF has not conducted any research on strong-post W-beam guardrail systems where rupture concerns were fixed with a single 10-gauge rail instead of nested 12-gauge rails. However, MwRSF had proposed this option as one of many solutions for the original rupture observed in testing the Nebraska W-beam guardrail over a 4" tall concrete curb. In the end, two nested 12-gauge rails were used and provided successful performance. I would suspect that a single 10-gauge W-beam may also have worked to mitigate rupture concerns.

If single 10-gauge rails are desired as a replacement for all systems which use nested 12-gauge rails, it may be necessary to further investigate some of the more critical impact scenarios and systems with computer simulation and/or dynamic testing.

Please let me know if you have any further questions or comments on this matter. Thanks!

Short-Radius Guardrail

Question

State: IA
Date: 06-26-2012

I've got a few questions for you on the short-radius guardrail system that TTI successfully tested at TL-2:

1. It's my understanding that the maximum radius that can be used is 8 feet. Isthat correct?

2. We may have intersection angles that are less than or greater than 90 degrees. Can the 12.5-foot rail section be bent to angles other than 90 degrees? If so, should the number of CRT posts going around the curve remain unchanged? If bend angles other than 90 degrees are not allowed, how might you suggest we deal with such situations?

3. I see that the original Yuma County design incorporated a flare on the primary road side, but the TTI-tested version did not. Do you see any problems using a flare on the primary road side?

4. I understand that the rail height as tested was 27 inches. Do you see any issues with raising the rail to the FHWA-recommended minimum of 29 inches? How about to 31 inches? If so, do the holes in the CRT posts need to be shifted lower by 2 inches (or 4 inches)?

5. Any reason why we couldn't install this system with mid-span splices? How about with 12-inch blockouts?

Most of our rural sideroad intersections have radii in the 25- to 30-foot range. Do you have any other suggestions on how we might run guardrail around the corner in a manner that more closely matches the existing radius?

Thanks for your help.

Response

Date: 07-17-2012

Ron forwarded me your email to address your short-radius questions. However, before I can address them, I need to clear up which design we are referencing.

TTI developed and tested two short-radius designs. One was tested under the TL-3 criteria for NCHRP 230 and one was tested under the TL-3 criteria for NCHRP 350. Neither of these systems met the safety requirements or were implemented.

Recently, TTI sought TL-2 approval of the Yuma County short-radius design that was tested in 1988 at SWRI based on their engineering analysis. This system was tested under the PL-1 criteria of the AASHTO Bridge Specifications.

No current system has been successfully tested to TL-2. If you can identify which system you are referring to, I will take a shot at answering your questions.

Thanks

Response

Date: 07-17-2012

I was referring to the Yuma County design that - correct me if I'm wrong - has been accepted at NCHRP 350 TL-2.

Response

Date: 07-18-2012

I have looked over your short-radius questions and have comments below in red.

I've got a few questions for you on the short-radius guardrail system that TTI successfully tested at TL-2:

1. It's my understanding that the maximum radius that can be used is 8 feet. Is that correct?

    The Yuma County system was tested at SwRI with the 8' radius that TTI shows in their details. The performance of larger radii is not fully understood for this particular system as it only underwent limited testing. MwRSF has generally stated that smaller radii are more critical for short-radius designs. A smaller radius size will result in a stiffer curved section, while larger radii will tend to decrease the stiffness of the curved section. Based on the previous research, the use of smaller radii seems to demonstrate more promise for short radius designs. No one has successfully tested any short-radius system radii larger than 16' to either the NCHRP 230 or 350 criteria. As such, we cannot recommend increasing the size of the Yuma County system without further analysis.

    FHWA Technical Advisory T5040.32 recommends the use of a short-radius guardrail that was developed by the State of Washington. This design was tested under the impact requirements set forth in NCHRP Report No. 230. The crash testing demonstrated that the system could contain a 1,800-lb small car and a 4,500-lb sedan. However, the testing program was not complete, and the results were marginal in some cases. Guidance for installing the short-radius guardrail is given for systems with radii ranging between 8.5 and 35 ft. The technical memorandum also notes that testing conducted on a 35-ft radius Washington State design did not perform adequately when impacted at 60 mph by a large vehicle (4740 lbs). Satisfactory results were obtained for the 35-ft radius system when a test was performed at a reduced speed of 50 mph with the large vehicle.

    We currently have a project with Wisconsin DOT to evaluate the use of the Washington system with larger radii. This work is currently underway and should provide some guidance as to the use of larger radii with short-radius systems.

2. We may have intersection angles that are less than or greater than 90 degrees. Can the 12.5-foot rail section be bent to angles other than 90 degrees? If so, should the number of CRT posts going around the curve remain unchanged? If bend angles other than 90 degrees are not allowed, how might you suggest we deal with such situations?

It is very difficult for us to make recommendation on the Yuma County system regarding intersection angles other than 90 deg. Small variation in the bend angle should not affect the performance of the system greatly, but it is difficult to define what the magnitude of the acceptable angles would be. The angle of the sides of the system affects performance as the smaller the angle, the stiffer and more energy the system absorbs when vehicles impact on the nose due to the angle that the guardrail is bent during impact. Obviously, as the angles vary a great deal from 90 deg. we begin to approach either a general curved guardrail system or a bullnose system. Thus, it would be possible to employ a bullnose design with flared sides on the very small interior angles or to follow guidance for curved guardrail on very large angles. However, specific guidance on intermediate angles is hard to give without further study, especially on a system where we have only limited test data.

3. I see that the original Yuma County design incorporated a flare on the primary road side, but the TTI-tested version did not. Do you see any problems using a flare on the primary road side?

   The use of the flare in the system should be acceptable. We actually employed a parabolic flare in the MASH short-radius system we partially developed. The use of the flare helped reduce the potential for the vehicle to be impaled by the guardrail rail if the vehicle impacted directly along one of the sides of the system.

4. I understand that the rail height as tested was 27 inches. Do you see any issues with raising the rail to the FHWA-recommended minimum of 29 inches? How about to 31 inches? If so, do the holes in the CRT posts need to be shifted lower by 2 inches (or 4 inches)?

   We would not recommend changing the rail height of the system. Our experience with testing the small car vehicles with the bullnose and short-radius systems has shown that the small car would be very likely to underride the system if the guardrail height were increased. If you desire to attach the system to a run of 31" high MGS, you can employ a height transition. In the past, our recommendation has been to transition the 3.25" height difference over approximately 50 ft or two 25-ft long sections of W-beam guardrail.

5. Any reason why we couldn't install this system with mid-span splices? How about with 12-inch blockouts?

   We see no issues with using midspan splices or 12" deep blockouts in the system.

Most of our rural sideroad intersections have radii in the 25- to 30-foot range. Do you have any other suggestions on how we might run guardrail around the corner in a manner that more closely matches the existing radius?

As noted in the discussion of larger radii above, there is only limited testing of larger radius systems and that was mostly done under the NCHRP 230 or PL-1 guidance. Thus, we are leery of increasing the radius of the Yuma County system. The best guidance at this time is the FHWA memo noted above. In addition, you may want to contact Roger Bligh at TTI and see if they investigated the use of larger radii with the Yuma County design. Finally, the work we are doing with WisDOT should shed some light on the subject as well.

Attachment: http://mwrsf-qa.unl.edu/attachments/b82bbf8953b9b18f96febea7d6c821f8.pdf

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Response

Date: 07-18-2012

Thanks, Bob. In your answer to my #2 question, you mention following "guidance for curved guardrail." May I ask to what guidance you are referring?

Response
Date: 07-18-2012
I saw that coming as soon as I wrote that comment.

Currently, the guidance on curved guardrail systems is pretty limited. . One research study regarding vehicle accidents or curved roadways and testing of W-beam guardrail on curves was conducted by ENSCO and sponsored by FHWA in 1989 through 1991. This research study involved the testing and evaluation of strong-post, W-beam guardrail systems that were located on the outer edge of a horizontal curve with a 1,192-ft radius. For this study, the successful safety performance of the curved W-beam barrier system was observed on flat ground for an 1,800-lb small car and a 5,400-lb pickup truck impacting at 60 mph and 20 degrees using flat roadway conditions. However, three subsequent pickup crash tests were unsuccessful (i.e., each resulted in vehicle rollover) when the W-beam guardrail system was installed in combination with a super-elevated, curved roadway. These crash tests were performed using the impact safety standards found in NCHRP Report No. 230 and the AASHTO 1989 Guide Specifications for Bridge Railings. As such, no strong-post, W-beam guardrail systems have been successfully tested for use on super-elevated, curved roadways according to NCHRP Report No. 350 safety performance guidelines or the current Manual for Assessing Safety Hardware (MASH). Because the ENSCO research study is the only available testing of beam guardrail on curved roadways, designers are limited to guidance on the installation of W-beam guardrail on curves based on limited tests of curved guardrail on flat ground and the use of engineering judgment.

At this time, NCAC has an NCHRP project, NCHRP 22-29 Performance of Longitudinal Barriers on Curved, Superelevated Roadway Sections, to further investigate those installations. This together with the WisDOT study we are doing should hopefully further our understanding of guardrail on curves.

Temporary Concrete Barrier Crossing Expansion Joints

Question

State: IL
Date: 07-25-2012

Please see the attached photo of an inverted U shape connector placed over a TCB at a bridge expansion joint. The device is bolted to the top of the barrier on one side and free to slide on the other.

Apparent concern is for transfer of tension across the joint. Does this present a pocketing potential?

We are pursuing changing this to overlapped runs of TCB, about 100' overlap total. However, width will preclude achieving 2' separation of the two runs. So either method leaves some concern.

Any comments and suggestions would be welcomed.

Response

Date: 08-17-2012
I am unable to find the attached photograph. We have had technical difficulties with this site in recent months. Can you please email me directly or repost the photograph. Thanks!

T-Intersection Guardrail

Question

State: KS
Date: 08-01-2012

We need a radius design or wrap around type guardrail. We are still using the Yuma County design from years ago. I have requested this project for several years now and I thought that this project was going to be presented to TRB research. Can you update me on this...Thanks!

Response

Date: 08-02-2012
You inquired as to whether any other work had been completed on the existing short radius guardrail systems. You are correct that TTI did publish a TRB paper on the Yuma County system, which was also presented at TRB and published in TRR 2262 (January 2011). For this effort, TTI slightly modified the design and demonstrated that it would meet NCHRP Test Level 2.

On a side note, NDOR has funded a new concept development effort to rethink alternative solutions for treating hazards near intersecting roadways. The Phase I concept development study began in July and lasts 18 months.

MGS Culvert Applications

Question

State: KS
Date: 08-09-2012

What is the potential that the metric-height, W-beam guardrail system with half-post spacing that was previously developed for attachment to the top of concrete box culverts could be modified and used in combination with the MGS?

Response

Date: 08-09-2012
Some time back, you inquired into the metric-height, W-beam guardrail system with half-post spacing that was previously developed for attachment to the top of concrete box culverts. Specifically, you asked whether this design could be modified and used in combination with the MGS. In 2007, we addressed this issue and provided an opinion on this matter. I have copied the response from the prior email and placed it directly below.

NDOR

(3) No crash testing has been performed on an MGS guardrail system attached to a concrete culvert. MwRSF currently has a Phase I project (Year 18) to conduct the initial concept development for the MGS bridge rail system. Phase II funding will be requested in the Year 19 program. Once the MGS bridge rail is crash tested and successfully evaluated, it may be necessary to acquire a smaller research project to adapt the system to culverts (i.e., top of slab, top of headwall, or back side of headwall).

WY: Is it acceptable for us to adapt this design for use with the MGS? Given the MGS's improved performance, it would appear and acceptable design.

*****MwRSF: Due to the superior safety performance of the MGS, it is our opinion that the metric-height, W-beam guardrail system attached to concrete culverts should be capable of be adapted for use with the MGS. Since the MGS design will result in increased barrier deflections, it would be reasonable to increase the minimum post offset from 10 in. to 12 in. or more.

Metric-Height W-beam Guardrail Attached to Top of Concrete Box Culvert

Question

State: KS
Date: 08-10-2012

KsDOT called MwRSF to inquire about the status of a the previous request for FHWA approval of the NCHRP Report 350 tested metric-height W-beam guardrail attached to top of concrete box culvert.

Response

Date: 08-10-2012

In 2001, MwRSF conducted a series of NCHRP Report No. 350 full-scale vehicle crash tests on a metric-height, W-beam guardrail system attached to a concrete box culvert. The configuration include a half-post spacing for post anchored to the top of the box culvert and five half-post spacing beyond the culvert. One successful crash test was performed with the back of the post positioned 18 in. away from the culvert headwall. However, a second crash test was unsuccessful when the post was positioned 1 in. away from the culvert headwall. These results are summarized in MwRSF report no. TRP-03-114-02 as well as TRR No. 1853 (2003).

In late 2002, MwRSF submitted a request for FHWA acceptance with the posts positioned a minimum of 10 in. away from the culvert headwall based on extensive film analysis. Subsequent correspondence with FHWA ensued in 2003.

At the time, Dick Powers was reviewing and preparing FHWA acceptance letters. From the correspondence between FHWA and MwRSF, it became apparent that a couple of issues may create concern with the approval. First, FHWA desired that a more intense approach guardrail transition be included beyond that shown in the report even though the post behavior for the attached posts and embedded posts were nearly identical. The recommended transition included farther reduced post spacing and guardrail nesting; since, another Texas W-beam transition was used to attach to a very stiff Texas W-beam bridge railing. Second, there was a potential issue with the allowable lateral offset to the headwall. Based on a verbal discussion of these issues over the phone, we decided to pull the request for acceptance as we did not agree to the caviats that would be placed in the FHWA letter. Therefore, no final FHWA acceptance letter was published, even though preliminary discussions occurred while reviewing a draft letter. Some of the email correspondence has been obtained from the hard copy archives for this project.

Therefore, I would like to know what you would like to come out of this investigation and determine if some type of resubmission is desired for the metric-height guardrail system. It may be necessary for both MwRSF and KsDOT to have a phone conversation with FHWA to discuss our options as well. It may be the case that FHWA will no longer provide 350 approval letters for previously crash-tested systems. I look forward to hearing from you on this matter.

Response

Date: 08-10-2012

Per your request in a recent phone conversation, MwRSF will investigate and re-evaluate our prior request to seek acceptance of the system noted above as well as a similar system with the MGS. Thus far, I have found a copy of the original letter request, as contained in the attached pdf copy. However, I have not found the prior email correspondence on this matter between Dick Powers, FHWA, and MwRSF. I will look into our hard paper archives on this matter or contact FHWA to see if they have archived files regarding this request. I would think that we would need to start with original testing before moving on to MGS.

Attachment: http://mwrsf-qa.unl.edu/attachments/89ac295cd28c0be4ef4f1581665ce65d.pdf

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IH 43 NB at IH 39 SB Off Ramp

Question

State: WI
Date: 08-14-2012

We have a situation (see photos) where a wing wall is falling away from a bridge parapet. The maintenance staff has stabilized the wing wall, but there is still an issue with snag.

In 5 years the bridge will be replaced, but I don't want to leave this like this until then.

I was thinking that it may be possible to

1. Put an angled metal plate (1/2" A36 with some reinforcing struts and bolts to attach it to the parapet) over the snag point
2. Place additional thrie beam or beam guard placed near the toe of the parapet it (with appropriate blocks and connections) and have the additional thrie beam bend around the thrie beam transition.

Do you believe that either of these alternatives are feasible? Do you have other suggestions?

Attachment: http://mwrsf-qa.unl.edu/attachments/58f975dabe9aad81b565c511fcd11f04.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/f6f4899fa880cd1305662ab4f14c11ff.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/579ce665cfff6a8e54d020dc1ad6836e.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/406508ebe74c5f360481beaab7774d7d.JPG

Response

Date: 08-14-2012
More photos
Attachment: http://mwrsf-qa.unl.edu/attachments/4ce9027082fe9820c25e79918308f2e1.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/4ce9027082fe9820c25e79918308f2e1.JPG

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Attachment: http://mwrsf-qa.unl.edu/attachments/4ce9027082fe9820c25e79918308f2e1.JPG

Response

Date: 08-14-2012

One more.
Attachment: http://mwrsf-qa.unl.edu/attachments/63ded366e9b7fd1903e318b7aa4df42d.JPG

Response
Date: 08-14-2012
This one may be somewhat difficult but I offer the following:

(1) Bring w-beam rail away from sloped end or buttress with additional blockout.

(2) Within sloped end region, connect symmetric W-beam to thrie beam transition.

(3) Block W-beam to thrie beam transition away from sloped end as well.

(4) Connect nested 12-gauge or single 10-gauge thrie beam to downstream end of 10-gauge W-T section and attach across shifted/exposed joint.

(5) Block thrie beam away from parapet and slowly taper back to parapet face at end of 12-ft 6-in. section to reduce wheel snag concerns.

(6) Use thrie end shoe to anchor thrie beam to downstream parapet.

This is the best that I could come up for short turnaround.

Bullnose Foundation Tube at Post No. 1

Question

State: WI
Date: 08-24-2012

Are there any alternative options to the 8' long foundation tube current used at post no. 1 in the thrie beam bullnose barrier for installations where the full 8' embedment is difficult to achieve?

Response

Date: 08-24-2012

There may be a potential alternative for the long foundation tube. However, the shorter tube would use the standard 6-ft long tubes with channel strut between post 1 and post 2 or the next increment shorter (don't recall at moment) with channel strut and soil plates. In both cases, new holes would be needed in foundation tubes to lower strut to below grade versus above grade. For this design, the strut cannot be above grade as it caused vehicular instabilities in the bullnose crash test! Let me know if you need additional information on this.

If they cannot get the 8 ft tubes into the ground, they still need to acquire somewhat large depths within rock to place the other tubes.

Draft of Short Radius Guardrail Standard Drawing

Question

State: KS
Date: 08-27-2012

Attached to this e-mail is a draft of KDOT's short radius guardrail standard drawing, which I've updated for the MGS. I'm aware you and Scott have been communicating wrt to this topic and no approved system has been designed or tested for the MGS. KDOT is interested in modifying our existing standard drawing in accordance with TTI's analysis and report (see attached) in the hopes of submitting the standard drawing for federal approval to allow KDOT to use the system on our projects in the interim period until such a time an approved short radius system becomes available. Please take some time to review the attached drawing and make any appropriate comments. I look forward to hearing from you and greatly appreciate your help. Please call if you have any questions or would like to discuss this further.

Response

Date: 08-28-2012

I do not recall giving any guidance that would support the use of the MGS as a short radius guardrail system around the nose of the device. Scott may have to refresh my memory on this issue. It is possible that we would have discussed eventually transitioning the w-beam to MGS after traveling along each of the two sides. For high-angle impacts on the nose, there may be some concern that the small car cannot be captured and instead would underride the rail. In order to improve capture, many prior studies had investigated the use of a thrie beam rail in the nose section under TL-3 test conditions. Although some promise was revealed in testing of the latter design, the project was abandoned. Unfortunately, the configuration of the primary side became unreasonably long, which made the overall system impractical to install.

Currently, it may be necessary to utilize the existing Yuma County system or modifications noted by TTI. After traveling down the sides, then the guardrail could be transitioned to the MGS. Please let me know if you have any questions or comments regarding this information.

Tube Spec for PCB Tie-Down through Asphalt

Question

State: WI
Date: 09-06-2012

Could you review the questions below.

I don't think that there is an ASTM for the cold drawn DOM steel tube. I think that the information provide for this tube is adequate enough to get the correct steel.

Please see the attached detail for the USH 41 temporary barrier wall on structures with an asphaltic overlay. One comment we have recieved from the regional materials folks is that the mounting hardeware, in particular the steel tube. Is there an ASTM/AASHTO standard for the steel sleeve. We currently have a Cold Drawn DOM Steel Tube (Min 72 ksi Yeild Strength). Does this type of tube relate to an ASTM/AASHTO standard to ensure that the 72 ksi yeild strength is being met?

We also need information for the ASTM standards for the nut.

Attachment: http://mwrsf-qa.unl.edu/attachments/aa0f159570f3e77ffd2c0f7ef1c10795.pdf

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Response

Date: 09-06-2012

The material for that tubing is labeled wrong on the original drawing I sent (sorry). It lists the tubing as having a 72 ksi yield strength. It should have read a 60 ksi yield strength and a 72 ksi tensile strength.

The material used for the tube is Cold Drawn Seamless ASTM 519 tubing and the tube material should be AISI 1026 (UNS G10260) cold drawn steel tubing. Cold Drawn Seamless is made from 1026 (UNS G10260) steel in sizes through 9 Â½" OD.

http://www.matweb.com/search/DataSheet.aspx?MatGUID=f3e08781eced413ebd167d9a9d1211f2

Let me know if you need anything else.

Response

Date: 11-05-2012

Epoxy bolt question for BEAT-SSCC

Question

State: WI
Date: 09-17-2012

We are trying to figure out if we need to bolt through a parapet for a BEAT-SSCC crash cushion.

Â

Manufacturer's recommendation is:

Â

"Anchorage systems that develop the full capacity of the bolt may be used as an alternative to drilling through the concrete section."

Â

Manufacture indicates that the bolt that is used to mount the BEAT-SSCC to the parapet is:

Â

1" x 16" Hex Bolt Grade 5

Â

Total parapet width at the height that the bolts are going to be installed at is 11".Â Concrete strength is 4000 PSI.

Â

Is it possible to use epoxy or mechanical anchors?

Â

Response

Date: 09-20-2012
I have reviewed the BEAT installation you sent to see if the end bolts can be installed with epoxy.

Typically, when we determine if the bolts can be epoxied rather than through bolted we assume that the epoxied installation must be capable of developing the full tensile and shear capacity of the bolt in question. The ultimate shear and tensile capacity of the 1" dia. Grade 5 bolt are 41.98 and 72.72 kips, respectively. If the bolt shear occurs through the shank rather than the threaded section, the max shear load is approximately 94.2 kips.

I calculated the epoxy anchors based on Hilti RE 500 epoxy and assumed an embedment depth of 9". I also used an anchor spacing of 15.625" and an edge distance to the top of the parapet of 7". Hilti lists the ultimate bond/concrete capacity in shear and tension for a 1" anchor with 9" of embedment as 95.2 kips and 69.5 kips, respectively. When factors for anchor spacing and edge distance are applied, the shear and tension capacities of the concrete/bond become 95.2 kips and 54.2 kips, respectively. The tension number is likely too conservative as Hilti assumes unreinforced concrete. Thus, the actual tensile capacity is likely greater than 54.2 kips. I would assume that that the anchorage can safely achieve 60 kips with reinforcing steel present. Comparing those capacities with the steel strengths above, it is apparent that the epoxy anchor has sufficient shear capacity and is slightly lower in tension. We do not believe this is an issue as the combined loading on the end anchor bolts is primarily shear with some tension due to prying of the box beam away from the face of the parapet. This prying action will create some tensile loads in the bolt, but the box beam tubes cannot generate tensile loads in excess of 60 kips at the anchor locations prior to yielding. In fact, the yield of the tubing limits the pryout tensile loads on the anchor to under 40 kips.

However, a problem exists if you are installing the anchors with the epoxy. The epoxy bond capacities assume the use of all threaded rod of similar grade or fully threaded bolts. The thread will develop the epoxy capacity more effectively than a smooth shank. A smooth shank will tend to decrease the bond capacity significantly. Thus, we cannot depend on the epoxy anchor capacities above will be true unless a fully threaded section is used. The BEAT system may be designed such that the smooth shank is required to take the shear loads in the design rather than a reduced section due to threads. As such, we cannot recommend epoxy anchorage of the bolts due to concerns that the use of fully threaded sections would reduce the shear capacity of the anchorage below the design intent. You could contact the BEAT manufacturers to get their feedback if the use of fully threaded anchor sections is acceptable.

Response

Date: 09-20-2012

I talked with the manufacture. Threaded rods are acceptable. Do you have a recommendation on grade of threaded rod?

Response

Date: 09-21-2012

I would make the grade equivalent to the Grade 5 rod specified in the plans. Thus, A449 is the appropriate threaded rod spec. A193 B7 would be acceptable as well.

Replacement Criteria for Broken Strands of Cable

Question

State: WY
Date: 09-27-2012

Our maintenance personnel are asking how many strands of cable can be ruptured before cable replacement becomes necessary. I believe that Trinity has advised that if 3 or fewer strands in a single bundle are ruptured, the cable will still have adequate reserve. I believe the cable is 3 bundles, with 7 strands each (3x7). Please advise.

Response

Date: 09-28-2012

The decision on when to replace damaged 3x7 wire rope (3 strands of 7 wires each) in a cable system should be kept conservative due to the critical function it serves. In the past we have noted research into wire rope damage for rigging applications that suggested that several wires could be damaged or fractured in a strand as long as the fractured wires were relatively far apart. The argument for this approach was that the friction developed by the weave of the cable wires and strands should help develop the fractured wire over significant cable length.

However, this type of recommendation does not apply readily to wire rope used in cable barriers because of the difference in the application. For rigging applications, there is generally a significant factor of safety and the wire rope is not stressed near its ultimate capacity. In addition, the wire rope must have the ability to absorb energy in order to develop higher loads when used in a barrier impact. Due to these requirements, we would recommend replacing wire rope on a cable barrier if there is a single fractured wire in a strand or if there is visible plastic deformation and necking of individual wires in a strand. If wire fracture or necking of one wire in a strand is observed, it is safe to assume that the other wires in the strand were loaded at or near their plastic limit as well. Thus, the remaining ductility, internal energy, and capacity of the strand with the damaged wire is likely very low and subsequent loading of the cable will reach the limit of the strand capacity more quickly due to the reduced internal energy dissipation in the strand.

We would not recommend that you follow the Trinity recommendation of 3 damaged wires in the strand. This would indicate a strand that had very little remaining capacity and we would not consider it fit for service.

Response

Date: 09-28-2012

Thank you for your response. One additional point of information. The fractures don't appear to be caused by yield strain, but by some feature of the impacting vehicle actually cutting strands.

Response

Date: 10-22-2012

end of response

Codecs for Viewing Crash Tests Videos

Question

State: WY
Date: 09-27-2012

I just got a Windows 7 computer at work and have experienced problems viewing older crash test videos, most of which are taken with the high speed cameras. Sometimes the first few seconds will run, then they shut down. After doing some research on the internet, I found that apparently Microsoft has felt that some codecs pose a potential security threat to their operating systems so they furnish less out of the box. I have noticed this on several different computer manufacturers. Do you have codecs that can run these older videos and if so, how do you install them?

Response

Date: 10-23-2012
Attached is a zip file that contains two different files. The first executable file "iv5setup" is usually the one that needs to be installed. If you are still having problems after installing that one, then install the other executable file, "K-Lite_Codec_Pack_640_Full".

Attachment: http://mwrsf-qa.unl.edu/attachments/dfc39ceeb80ff6e1f84f75e714a5b51c.zip

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Clear Zone for Roadways with Design Speed of 70 mph

Question

State: WI
Date: 04-25-2012

We are looking to increase our posted speed of the rural freeways to 70 mph. We have a project that is looking to use a design speed of 75 mph. I was asked what should be the clear zone for a 75 mph design speed.

I believe that some of the work Dr. Sicking put together for the NCHRP Report 665 may be able to provide guidance.

Response

Date: 09-28-2012

The clear zone adjacent to high speed roadways was originally determined from lateral encroachment data collected adjacent to high speed test tracks at General Motors. Every ran-off-roaad event was identified and investigated to determine the vehicle trajectory after leaving the roadway. The distribution of lateral travel distances was developed from these accident investigations and the national clear zone distance for high speed highways was set equal to the 70th percentile lateral encroachment distance.

This same approach can be used to estimate the appropriate clear zone distances for high speed highways using data from NCHRP Report 665. This study collected more than 800 vehicle trajectories from single-vehicle, ran-off-road crashes on high speed roadways. Further, the crash sampling method produced a large bias toward severe crashes. Thus, even though approximately half of these crashes involved impacts with fixed objects which may tend to shorten the lateral travel distances, the large bias toward more serious crashes should produce the opposite effect. Thus, the data from NCHRP Project 665 is believed to be the best source of vehicle trajectory data currently available.

Unfortunately, the number of crashes collected from 75 mph highways was somewhat limited. When lateral encroachment data from controlled access highways with 70 & 75 mph speed limits is examined, the 70th percentile lateral encroachment was found to be 10.5 m or 34.5 ft. This value closely matches the Roadside Design Guide recommendation of 32-35 ft for 70 mph highways. Historically, encroachment data has been extrapolated to higher speed facilities by incorporating 80th percentile encroachment distances. The 80th percentile encroachment distance from the curve below was found to be 13 m or approximately 43 ft.

The appropriateness of using this approach to extrapolate encroachment distances to higher speed limit facilities was then evaluated by using data from 65 mph highways to estimate the appropriate clear zone at 70 mph. As shown in the figure below, the estimated clear zone width for 65 and 70 mph roadways was found to be 8.3 and 10.4 m respectively. The close correlation between the two estimates for 70 mph roadways and the correlation with the RDG provide strong support for the method used to estimate appropriate clear zone for 75 mph highways.

Attachment: http://mwrsf-qa.unl.edu/attachments/4f9bc375ddab920ba77c232736c4158a.pdf

How much of a 2:1 do we need behinded a beam guard post

Question
State: WI
Date: 11-01-2012

There is a project that may have to install beam guard near a body of water. The are asking how far down the slope do they need to carry the 2:1?

I know that the attached drawing show 2.5:1.

Attachment: http://mwrsf-qa.unl.edu/attachments/253137118ac5245d984b54d01f4b950a.pdf

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Response
Date: 11-01-2012
We would recommend that a minimum of 4 ft of the 2:1 slope be maintained prior to switching to a steeper slope. This length should provide sufficient soil at the 2:1 slope to resist post rotation in a manner similar to the continuous 2:1 slope that was tested.

Allowable exposed offset for PCB to median gate attachment hardware

Question

State: WI
Date: 11-07-2012

WisDOT is planning on installing some median gates with temporary barrier. The manufacturer's drawings indicate that the face of thier gate anchorages and the face of our temporary concrete barrier will not be flush. One manufacture indicated that the difference could be up to 1".

How much of a difference between the face of our barrier and their anchorage would be considered a snag issue?

I believe that there was some crash testing done at MwRSF indicating that 3/16 or 1/4 inch plate caused a vehicle to roll over. Would this be a good rule of thumb with steel?

Shouldn't manufacturers be able to provide gates that don't have snag issues with out doing a crash test or significant amount of engineering?

Thanks

Response

Date: 11-14-2012

I have some comments regarding the use of median barrier gates with TCB segments as well as the snag issue you brought up.

First, you are planning to install a median gate system on a run of TCB's. This type of installation poses some concerns as median gate systems were typically designed and tested with permanent concrete parapets. Thus, you will likely need to anchor both sides of the TCB segments adjacent to the gate in order to provide similar deflection performance as compared to a rigid parapet. Currently, we do not recommend anchoring on the front and back sides of a TCB system. However, we have seen in past testing that pins on the backside of a barrier may cause excess rotation and tipping of the barrier which in turn can produce vehicle instability. Thus, we currently do not recommend pinning on both sides of the PCB when placed in the median except for the transition section which we tested. In addition, anchoring both sides of the TCB system will still allow some level of deflection which will be greater than the rigid parapets the median gates were designed and tested with. Thus, there are concerns that the use of a median gate system may be affected in some manner when used with anchored TCB's.

That said, your original question was regarding the level of vertical asperity that can be present on the face the barriers due to the attachment of the steel gate hardware to the TCB segment. Previous research has shown that vertical asperities can affect vehicle stability in a negative manner.

1. MwRSF conducted testing on an anchored steel temporary barrier section formed by welding together stacked steel H-sections. The H-sections were connected using 3.5"x15"x0.375" vertical steel plates. In the first test of the system, test no. HTB-1, the 2000P vehicle impacted the barrier and rolled. From an analysis of the test results, MwRSF researchers believe that the rollover was caused by snagging of the pickup truck on the barrier. More specifically, the steel rims and sheet metal snagged on the 3/8" thick vertical straps holding the barriers together, the separation between the barrier joints, and the top of the barrier section. This conclusion was based on the damage to the vehicle's right-side sheet metal and steel wheel rims as well as the right-front fender being pulled down during the test as observed on the high-speed film.

Following this investigation, MwRSF researchers determined that the safety performance

of the H-section temporary barrier tie-down system (Design No. 1) could be significantly improved by reducing the potential for snag. In order to eliminate the snag potential, two modifications were made to the barrier tie-down system. First, the vertical steel straps positioned on the traffic-side face of the barrier were removed and replaced with a longitudinal seam weld. Second, the anchor bolts used in conjunction with the drop-in anchors were changed from ASTM A325 to ASTM A307 grade bolts. The bolt grade reduction was made in order to reduce the load capacity of the tie-down attachments and allow for a slight increase in the deflection of the system. It was believed that allowing slightly higher deflections would potentially reduce any additional vehicle snag on the top of the barrier section and at the joints.

A second test, test no. HTB-2, was performed on the modified system with

a Â¾-ton pickup truck and was determined to be acceptable according to the TL-3 safety performance criteria presented in NCHRP Report No. 350.

Based on this research, it would appear that vertical asperities of 3/8" or more can contribute to vehicle instability.

The file 'HTB.zip' (23.5 MB) is available for download at http://dropbox.unl.edu/uploads/20121128/6cb3d21f9c7e7a96/HTB.zip

for the next 14 days.

It will be removed after Wednesday, November 28, 2012.

2. Previously, MwRSF has provided guidance with respect to the allowable offset for alignment of permanent concrete parapets and temporary concrete barriers.

With regards to permanent concrete barrier, we would recommend keeping the lateral offset or alignment offset minimized to eliminate snag. Variations of 1" or less would be preferred.

For the temporary barrier installation shown in your photo, we would prefer that the alignment gap be 1" or less, but we believe that gaps as large as 2" are likely permissible. The rationale behind the larger alignment gap allowance is that temporary barrier segments will move when impacted and cause changes in the alignment gap as the impacting vehicle reaches the barrier joint. Thus, a joint that has a given initial alignment will move change alignment as the barrier is impacted. This allows for more tolerance for the temporary barrier gap. Alignments gaps larger than 2" would indicate problems with the temporary barrier joint and would require investigation.

Keep in mind that these gaps were specific to concrete barrier overlaps where the concrete would be expected to fracture and give when snagged.

3. TTI conducted research in NCHRP 554 regarding aesthetic barrier design and the size of vertical asperities allowable for concrete barriers. This research found a range of performance for vertical asperities dependent on the angle, depth, and the width between asperities. Crash testing conducted as part of this project found that vertical concrete ridges as deep as Â½" could result in failure. Further simulation analysis found that vertical steps of Â¼" were acceptable.

In addition to the above studies, there is some concern that gaps between the sheet metal of the gate system and the concrete barrier could be opened further during impact and increase vehicle snag as well as compromise the structure of the gate connection. As such, we would recommend keeping the gap to a minimum. This should be achievable through using steel plates to bridge from the exposed edges of the gate hardware until it is flush with the surface of the PCB. The thickness of these plates should likely be limited to Â¼" based on the issues with 3/8" plate in the HTB testing and the results of NCHRP 554.

CRT posts behind a curb

Question

State: IA
Date: 11-20-2012

We have an MGS post conflict at an existing curb intake. As you have recommended, we will be installing the MGS long-span system to skip one post at the intake, placing three CRT posts upstream and downstream of the unsupported section.

Since the CRT posts will be installed behind a curb, must we adjust the location of the weakening holes so that the center of the top hole is flush with the ground line? Or can we still use the CRT posts that were utilized in the long-span crash tests (top hole centered 32" from top of post)?

Response

Date: 11-21-2012

In this situation, we would recommend that both the CRT holes be adjusted upward to account for the additional soil behind the curb. Thus, if a 6" curb was used in the installation, we would recommend that both the upper and lower holes in the CRT post be shifted 6" up on the post. Post embedment can remain the same (in this case slightly increased from a standard installation due to the curb).

The rational for shifting the holes is related to the function of the holes in the post.The holes reduce the cross-section of the post and act to weaken the post in bending and in shear. However, if the hole that is typically at groundline is buried, then the cross-section of the post is not weakened for shear loads across the base of the post at groundline, and the post may not fracture as designed. The bending section would still be reduced even with the hole being placed below groundline. Because the CRT is used with a curb in this case, the vehicle bumper may impact the post lower than a typical installation. Thus, the shear fracture of the post may become more critical. Thus, we recommend relocating the holes in the post as noted above.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #55		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Increased Span Length of the MGS Long Span		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211081001	**Other Project ID (i.e., contract #):** RPFP-13-UBSP	**Project Start Date:** 7/1/2012
Original Project End Date: 6/30/2015	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$65,224	$28,393	40%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$28,280	

Project Description:

MwRSF has recently developed a Universal Breakaway Steel Post (UBSP) for use in the thrie beam bullnose system. The satisfactory performance of the UBSP in the bullnose median barrier system would suggest that there is potential for the UBSP to be used as a surrogate in other CRT applications, such as in the long-span guardrail system, guardrail end terminals, guardrail systems installed in subsurface rock foundations or rigid pavement mow strips, future short-radius guardrails, and new, reduced maintenance barrier systems. However, further analysis and testing would be required to verify its performance in these other guardrail applications. Thus, there exists a need to conduct further analysis and testing of the UBSP in order to investigate its feasibility for use in other barrier systems.

Objectives / Tasks

1. Dynamic bogie tests (8 total)
2. Data analysis and evaluation
3. Ulterior systems design recommendations
4. Written report documenting all testing, analysis, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, the eight originally proposed dynamic bogie tests were conducted. This quarter, the test results were analyzed and compared. Results between the baseline wood CRT posts and the steel breakaway posts look very similar for strong axis rotation, while the steel posts produced only slightly less resistances than the wood posts during weak axis rotation tests. Thus, the use of the steel breakaway posts in multiple CT applications looks promissing.

Anticipated work next quarter:

Work on the report documenting all testing, analysis, and conclusions shall begin. Additionally, conclusions shall be drawn concerning the use of steel breakaway posts instead of wood CRT posts.

Significant Results:

All eight of the originally proposed dynamic bogie tests have been conducted. The data has not yet been analyzed.

Objectives / Tasks	% Complete
1. Dynamic bogie tests (8 total)	100%
2. Data analysis and evaluation	80%
3. Ulterior systems design recommendations	0%
4. Written report documenting all testing, analysis, and conclusions	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

Further analysis and development of the UBSP post would aid designers by providing a potential surrogate post design for current CRT applications. Because the UBSP design is fabricated from steel, its use offers several benefits over timber posts, including reduced variability, reduced concerns for deterioration over time, and alleviation of environmental concerns regarding disposal of wood posts with preservative treatment.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #56	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Increased Span Length of the MGS Long Span	

Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-13-MGS-3	**Other Project ID (i.e., contract #):** 2611211082001	**Project Start Date:** 7/1/2012
Original Project End Date: 6/30/2015	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$212,730	$0	0%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$0	

Project Description:

The current MGS long-span guardrail system provides the capability to span unsupported lengths up 25 ft. While this span length has many useful applications, many culvert structures exceed the span length of the MGS long-span system. Other solutions for mounting guardrail to culverts exist, but mounting hardware to culverts can also cause difficulties. If the long span can be adjusted to accommodate longer spans, the difficulties associated with mounting hardware to the culvert can be avoided.

The objective of this research effort is to design and evaluate the MGS long-span design for use with unsupported spans greater than 25 ft. The research effort could be focused in one of two directions. The research could focus on determination of the maximum unsupported span length for the current long-span design or it could focus on evaluating potential modifications that may allow for significantly longer unsupported spans. The increased unsupported span design would be designed to meet the TL-3 safety criteria set forth in MASH.

Objectives / Tasks

1. Literature review of previous long-span systems
2. Simulation of both original and any new long-span system designs
3. Design modifications to extend unsupported length
4. Full scale crash testing of new design (two MASH 3-11 tests)
5. Data analysis and evaluation
6. Written report documenting all design work, simulation, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Work on this project has not begun

Anticipated work next quarter:

It is anticipated that the literature review will begin next quarter

Significant Results:

None

Objectives / Tasks	% Complete
1. Literature review of previous long-span systems	0%
2. Simulation of both original and any new long-span system designs	0%
3. Design modifications to extend unsupported length	0%
4. Full scale crash testing of new design (two MASH 3-11 tests)	0%
5. Data analysis and evaluation	0%
6. Written report documenting all design work, simulation, testing, and conclusions	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This project has a cost of $249,335. There was insufficient funding in Pool Fund Year 23 to fund this entire amount. Thus, The budget for Year 23 is $212,730, and the remaining $36,605 is being funded by contingency funds in Pool Fund Year 23.

Potential Implementation:

The MGS long-span system has the ability to perform safely without nested rail and with a minimal barrier offset. These features make the barrier a very functional, efficient, and safe option for protection of low-fill culverts. Development of an increased unsupported span length for the MGS long-span system will add to the flexibility of the design and provide for improved protection of culvert headwalls and vertical dropoffs with a length greater than 24 ft.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #57	**Transportation Pooled Fund Program - Report Period:** ☐ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☑ Quarter 4 (October 4 – December 31)

Project Title:
Increased Span Length of the MGS Long Span

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Bielenberg, Lechtenberg	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211083001	RPFP-13-MGS-5	7/1/2012
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2015		

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$162,896	$0	0%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$0	

Project Description:

Over the years, it has become desirable to place a longitudinal concrete slab or continuous asphalt pavement under W-beam guardrail systems in order to reduce the time and costs for mowing operations around guardrail posts. Likewise, many times guardrail posts must be installed in un-yielding pavements. Unfortunately, the placement of guardrail posts in pavement restricts energy dissipation by restricting the posts from rotating through the soil. Thus, installations in pavements have incorporated a blocked-out area or "leave-out" that surrounds each post. These leave-outs allow post rotation in the soil and result in acceptable safety performances for standard W-beam guardrails.

Recently, the MGS Bridge Rail was developed and successfully crash tested under the TL-3 MASH guidelines. This system utilized weak steel posts placed in tubular steel sockets that were side-mounted to a concrete bridge deck. The energy dissipation mechanism for this system was designed as bending of the weak posts instead of post rotation through soil. Since the posts are installed in rigid sleeves, MwRSF believes that the MGS Bridge Rail could be adapted for use in guardrail applications where mow strips are required. In this situation, it would be unnecessary to provide large leave-outs around the posts of guardrail systems installed in un-yielding pavements. Thus, The objective of this research effort is to adapt the MGS Bridge Rail system for use in mow strips and other pavements.

Objectives / Tasks

1. State survey of existing mow strip practices
2. System design and analysis
3. Dynamic bogie component testing
4. Full scale crash testing (MASH 3-10 and 3-11 tests)
5. Data analysis and evaluation
6. Written report documenting all design work, simulation, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Work on this project has not begun

Anticipated work next quarter:

It is anticipated that the State survey of current mow strip practices will be conducted in the next quarter

Significant Results:

None

Objectives / Tasks	% Complete
1. State survey of existing mow strip practices	0%
2. System design and analysis	0%
3. Dynamic bogie component testing	0%
4. Full scale crash testing (MASH 3-10 and 3-11 tests)	0%
5. Data analysis and evaluation	0%
6. Written report documenting all design work, simulation, testing, and conclusions	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

Adapting the MGS bridge rail to be placed in various pavements will allow designers to install the weak post, MGS system in mow strips without requiring leave-outs, breakaway posts, or other additional hardware. It is anticipated that the new post foundation design will significantly reduce labor and system costs associated with installation, repair, and maintenance of guardrail installed in mow strips and other pavements. Insight will also be gained regarding the potential performance of other weak post guardrail systems when installed in mow strips.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Supplement #58 Pooled Fund Project RPFP-13-AGT-1		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Dynamic Testing and Evaluation of Curb and Gutter Placed Under Asymmetrical Section of MGS Thrie Beam Transition		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-6864	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: 2611211084001	**Other Project ID (i.e., contract #):** RPFP-13-AGT-1	**Project Start Date:** 7/1/2012
Original Project End Date: 6/30/2015	**Current Project End Date:** 6/30/2015	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$154,217	$57,778	38%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$27,261 (18%)	$27,261	38%

Project Description:

Recently, MwRSF researchers successfully developed and crash tested a simplified, steel-post stiffness transition for adapting the 31-in. tall Midwest Guardrail System (MGS) to existing, thrie beam approach guardrail transition systems. This system utilized an asymmetrical transition section, which maintained a top mounting height of 31 in. The system was successfully crash tested to TL-3 impact safety standards of MASH. However, this simplified stiffness transition system was not evaluated with a lower concrete curb placed below the rail.

Concrete curbs are often installed below approach guardrail transitions to increase hydraulic capacity, control water runoff, and mitigate concerns for soil erosion near bridge ends. As such, many states are interested in placing curbs underneath and throughout the length of common approach guardrail transitions. However, the addition of a curb below a transition rail element can potentially lead to severe consequences. Specifically, small car vehicles may become wedged between the bottom of the asymmetrical rail and the top of the curb. This snag event could lead to excessive vehicle decelerations, increased risk to occupants, and vehicular instabilities. Light truck passenger vehicles may climb the curb and contact the rail with the vehicle c.g. positioned higher than normal, thus potentially causing excessive vehicular instabilities, and even rollover, during redirection. Unfortunately, no crash testing has been performed near the upstream end of the new simplified stiffness transition to thrie beam approach guardrail transitions where curbs are placed directly below the asymmetrical transition element. Therefore, full-scale vehicle crash testing is deemed necessary to verify the safety performance of curb placement below the asymmetric transition element.

Objectives / Tasks

1. Full-scale crash testing (MASH test designation nos. 3-20 and 3-21).
2. Data analysis and evaluation.
3. Report documenting R&D effort, including brainstorming, redesign, construction, crash testing, conclusions, and recommendations.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Following unsuccessful crash test MWTC-1 with an 1100C small car, MwRSF examined the test results and made recommendations to Pooled Fund members on how to proceed with the project via an email dated November 1, 2012.

The first crash test on the stiffness transition to a thrie beam approach guardrail system with lower curb involved an 1100C small car impacting at the TL-3 conditions found in MASH. This small car test was performed to evaluate the tendency for the small car to become wedged under the asymmetrical W-beam to thrie beam transition element with a 4-in. tall concrete curb placed under the entire barrier system. During the test, components of the small car penetrated under the W-beam rail, while the wheel overrode and/or climbed up the curb. These events led to heavy upward and lateral vehicle loading on the lower region of the W-beam rail in advance of the splice between the W-beam and asymmetrical segment. The W-beam rail ruptured at the splice location, gave way, and allowed the vehicle to snag on a stiff rail element in combination with several exposed transition posts. Due to rail rupture, MwRSF was unable to evaluate the potential for the small car to become severely snagged under and on the lower sloped region of the asymmetric section with lower curb.

In recent years, MwRSF successfully conducted a small car crash test on an identical stiffness transition but without a curb extending along the barrier and under the stiffness transition region where the asymmetrical element is located. No other barrier differences were incorporated. Kia Rio small car vehicles were used in both crash tests but with different model years due to different periods of testing - 2002 and 2007. Although limited data is available, our testing personnel have noticed some changes in vehicle structure near frame rail, engine compartment, and quarter panel.

It is our opinion that the presence of a curb under the MGS near a stiff transition likely changed the load direction and magnitude to the guardrail in advance of the splice location. The presence of a curb may also have provided increased

Anticipated work next quarter:

To date, two small car crash tests (test nos. MWTC-1 and MWTC-2) have been performed on the MGS stiffness transition with lower concrete curb - one with unsatisfactory results and one with acceptable results. Since this effort was budgeted with only one 1100C test and one 2270P test, it is necessary to still conduct a 2270P test in order to demonstrate that MGS stiffness transition with lower concrete curb meets the MASH TL-3 impact safety standards.

At this time, it would be cost-effective to use the remaining project funds to remove the damaged hardware, repair the barrier and curb systems, and conduct a 2270P crash test, if approved by Pooled Fund members. If a 2270P test is approved, conducted, and found to provide acceptable results, then the documentation and reporting of all three crash tests would be initiated by using any remaining projects funds following the 2270P test. However, it may not be possible to complete the entire project reporting with existing funds due to running a third test that was not budgeted. Additional contingency funds would be requested in the future if the 2270P test is authorized.

Significant Results:

Test no. MWTC-1 (MASH test designation no. 3-20) illustrated that the placement of a 4-in. tall curb in combination with the MGS stiffness transition with asymmetrical transition rail element can significantly degrade barrier performance from that observed when the curb was not installed. The 1100C full-scale crash test resulted in rail rupture at the upstream end of the asymmetrical W-beam to thrie beam transition element, and the vehicle snagged on several transition posts.

Test no. MWTC-2 (MASH test designation no. 3-20) demonstrated that the use of 12 ft - 6 in. of nested W-beam rail in advance of the asymmetrical segment was able to mitigate factors that led to guardrail rupture. In addition, this small car re-test showed that the MGS stiffness transition in combination with lower curb met the TL-3 MASH impact safety standards when used with 12 ft - 6 in. of nested W-beam rail.

Objectives/Tasks	% Complete
1. Full-scale crash testing (MASH test designation nos. 3-20 and 3-21).	50%
2. Data analysis and evaluation.	20%
3. Report documenting R&D effort, including brainstorming, redesign, construction, crash testing, conclusions, and recommendations.	5%

**A formal request will be forthcoming to utilize remaining project funds to conduct the 2270P crash test on the modified barrier system.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

At the present, two 1100C small car crash tests have been performed. Due to a failure in the first test, a second small car crash test was performed on a modified barrier system. The project contained two budgeted crash tests - one 1100C small car and one 2270P pickup truck. A third test with a 2270P pickup truck is still needed to demonstrate acceptable safety performance for the MGS stiffness transition with lower curb. It is timely to conduct this test now while the core system remains on site and ready for repair. Sufficient project funds remain to conduct the physical test, although it is uncertain if the entire documentation and reporting can also be completed. It is believed that contingency funds could be reallocated in the future to complete the later effort.

Potential Implementation:

The successful crash testing of the MGS stiffness transition with asymmetric transition element and lower concrete curb will allow state department of transportation personnel to provide continuous hydraulic runoff control between approach guardrail transitions and W-beam approach rails. The use of continuous concrete curb will help to mitigate soil erosion near bridge ends as well as its costly maintenance and repair.